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ARTICLE

Cognitive mechanisms in simile and metaphor comprehension

Emma Krane Mathisen[1], Nicholas Allott[2] and Camilo R. Ronderos[3]

[1]Laboratoire de Linguistique Formelle, Université Paris Cité, Paris, France; [2]Department of Literature, Area Studies and European Languages, University of Oslo, Oslo, Norway and [3]Center for Languages and Literature, Lund University, Lund, Sweden
Corresponding author: Emma Krane Mathisen; Email: emma-krane.mathisen@etu.u-paris.fr

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Abstract
This study investigates whether metaphors and similes are processed the same way or not. Comparison accounts of metaphor claim that metaphors and similes use the same cognitive mechanisms because metaphors are implicit similes, while Categorization accounts claim that the two figures of speech require different cognitive mechanisms. It is unclear which position has the most support. We address this by introducing the distinction between *single* and *extended* metaphors to this debate. Several experiments have shown that a metaphor preceded by another metaphor is read faster than a single metaphor. If similes in extended and non-extended contexts display a similar processing difference, this would support views saying that metaphors and similes are processed the same way. If not, it would be more in line with the view that they are processed differently. Using an eye-tracking reading paradigm, we find that the difference between processing single and extended metaphors does not hold in the case of simile comprehension. This is more compatible with Categorization accounts than with Comparison accounts; if the cognitive mechanism behind metaphor and simile processing is the same, we would expect there to be a comparable processing difference between metaphors and similes in the single and extended conditions.

Keywords: experimental pragmatics; eye-tracking; figurative language; language processing; metaphors; pragmatics; similes

1. Introduction

Metaphors present a puzzle. On the one hand, language users rely on conventional meanings to communicate efficiently. On the other hand, we can spontaneously use words in novel ways that radically depart from their literal meaning with relatively little effort. How are our addressees able to derive such intended metaphorical meanings on the fly?

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One possible answer to the question asked above stems from research on the commonalities between metaphors and similes. It is intuitive to compare metaphors and similes, since, at first glance, they do not appear to be very different. Nominal metaphors (i.e., metaphors where vehicle and topic are nouns) can in many cases be transformed into a simile simply by adding a comparison term without dramatically changing the utterance's figurative meaning:

1) My best friend is a comforting blanket.
2) My best friend is like a comforting blanket.

A possible interpretation of the metaphor in example (1) is that the speaker's best friend brings them safety and is comfortable to be around, and a similar interpretation can be reached for the simile in example (2).

Such observations have inspired some scholars to argue that metaphors are in effect implicit similes (e.g., Bowdle & Gentner, 2005; Grice, 1975; Ortony, 1979; Tversky, 1977) and as such are interpreted as a form of comparison. The structures of the metaphoric vehicle and topic are aligned and compared, which allows for inferences to be projected from vehicle to topic based on this initial structural alignment (see Gentner et al., 2001).

Others maintain that the interpretative processes involved in the two figures of speech work differently (Glucksberg, 2001, 2008; Glucksberg & Haught, 2006; Sperber & Wilson, 2008). These researchers argue that while similes are understood via comparisons, metaphor comprehension unfolds as a type of local adjustment of meaning: The metaphoric topic (together with the utterance's context) provides a set of interpretative constraints that allow for the meaning of the vehicle to be adjusted on the fly, creating what is referred to as an *ad hoc category*, of which the topic is then perceived to be a member.

Several studies have provided evidence bearing on this debate, with some supporting the implicit comparison view and others the local adjustment view (see for example Gentner & Bowdle, 2008; Glucksberg & Haught, 2006; Glucksberg & Keysar, 1990; Jones & Estes, 2006; Ronderos & Falkum, 2023; Rubio-Fernández et al., 2016). After several decades, the debate has largely stalled (see Holyoak & Stamenković, 2018, for a comprehensive review). This stalemate has led some researchers to argue that it is necessary to move beyond the study of nominal metaphors such as example (1) to better understand the mechanisms responsible for metaphor comprehension (Holyoak & Stamenković, 2018; Ronderos et al., 2021, 2023). To counter the excessive attention paid to nominal metaphors, recent metaphor research has focused on a wider variety of metaphors, such as verbal metaphors (King & Gentner, 2023; Ronderos et al., 2021), verb-object metaphors (Ronderos et al., 2023), multimodal metaphors (Bambini et al., 2024) and *extended metaphors* (Rubio-Fernández et al., 2016; Ronderos & Falkum, 2023). Extended metaphors contain several metaphoric vehicles connected to the same conceptual domain, and the related vehicles contribute to an extended figurative meaning, as in example (3):

3) Noah spends four hours a day in the gym. He *forges* his body intensively. His muscles are *steel* and he is very proud.

In example (3), both *forges* and *steel* are used metaphorically, and they create a figurative meaning which stretches across the whole utterance. Since the two

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metaphor vehicles have related figurative meanings that reinforce each other, this utterance is an extended metaphor.

The study of extended metaphors has focused on whether single and extended metaphors are processed via the same cognitive mechanisms and, consequently, require comparable amounts of effort to be processed. Within the local meaning adjustment view, one prominent account has posited that while single metaphors might be understood via a local process of meaning adjustment, the multiple metaphoric vehicles in an extended metaphor likely lead the metaphor as a whole to be processed differently (Carston, 2010). This posited distinction in processing has found support from experimental studies (Rubio-Fernández et al., 2016; Ronderos & Falkum, 2023), which broadly suggest that metaphors that appear inside a larger extended metaphor are processed in a qualitatively different way than when they are processed on their own as a single metaphor.

This established processing difference between single and extended metaphors gains broader significance in the context of the comparison between similes and metaphors: If the processing effort of a metaphoric vehicle changes as a function of whether it appears on its own or in the company of conceptually related metaphoric vehicles, would we find a similar effect for similes? And how can this comparison inform the debate on the processing mechanisms behind metaphor comprehension?

These are the questions addressed in this study. In an eye-tracking during reading experiment, we investigated the processing of single and extended metaphors as well as similes. Our goal was to compare the two in order to provide evidence bearing on the cognitive mechanisms involved in metaphor comprehension. In the following sections, we elaborate on prominent theoretical views of simile and metaphor comprehension, followed by those on extended metaphors and a survey of the relevant empirical studies. We then present our experimental investigation and discuss its contribution to the existing literature.

1.1. Understanding similes and metaphors

Some of the earliest known accounts of the relation between metaphors and similes come from classical rhetoric and poetics. The classical comparison view is that metaphors are in effect implicit similes, that is, figurative comparison statements that do not contain an explicit comparison term (see Hills, 2022; Holyoak & Stamenković, 2018). The most prominent modern comparison-based view is the *Structure Mapping* framework, which sees analogical reasoning as the cognitive mechanism responsible for processing both similes and novel metaphors (Bowdle & Gentner, 2005; Gentner et al., 2001; Gentner & Bowdle, 2008). Bowdle and Gentner (2005, p. 208) write that '[n]ovel metaphors are processed as comparisons, in which the target concept is structurally aligned with the literal base concept' and propose that structural alignment between the topic and vehicle (e.g., *best friend* and *comforting blanket*, respectively, in example 1 above) forms the basis of the metaphorical interpretation. In examples (1) and (2), for instance, predicates applying both to the topic and the vehicle could be *reassuring* and *familiar*. The local predicates are then coalesced into structurally consistent clusters, often referred to as *kernels* in the analogy literature (Gentner & Bowdle, 2008). The mapping of one-to-one correspondences of predicates from vehicle to topic forms the basis of the final interpretation of the metaphor or simile, and the addressee will reason analogically to merge

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structurally consistent kernels until the final interpretation is reached (Wolff & Gentner, 2011).

The most crucial feature of the Structure Mapping view for the purposes of this article is that it proposes the same processing mechanism for both similes and novel metaphors. Further, the Structure Mapping view predicts that novel similes will be processed more easily than novel metaphors. Gentner and Bowdle (2008) write that the grammatical form of a metaphor invites the reader to conduct a categorization, but that this process terminates because the vehicle of a novel metaphor does not have an established sense. The reader must then 'start over using a comparison process – a horizontal alignment with the literal concept evoked by the base' (Gentner & Bowdle, p. 120).

Whereas the Structure Mapping view predicts that novel metaphors and similes are both processed through analogical reasoning, Glucksberg and Haught (2006) and Sperber and Wilson (2008) argue that comprehension of novel metaphors is a categorization process. This involves local lexical modulation where the literal, or conventional, meaning of a term is adjusted to be contextually appropriate. In example (1) ('my best friend is a comforting blanket'), for example, the literal concept COMFORTING BLANKET would be adjusted to denote a contextually appropriate concept [COMFORTING BLANKET]* (we follow the convention within relevance theory of referring to literal concepts in capital letters and lexically adjusted concepts with capital letters followed by an asterisk). The lexically adjusted concept could express something like 'a person who makes you feel safe and comfortable'. The lexically adjusted concepts are commonly referred to as *ad hoc concepts*.

Glucksberg and Haught (2006) conducted experiments on the relation between aptness, novelty and processing type during metaphor comprehension. They found that novel, and not just conventional, metaphors may be comprehended faster than similes, which is at odds with the Structure Mapping position, as it argues that processing novel metaphors involves going from a categorization process to a comparison process (Gentner & Bowdle, 2008).

Wilson and Carston (2007) and Sperber and Wilson (2008) have also argued that metaphors are categorizations. In fact, they argue that the lexical modulation process applies to all instances of loose language; thus '[t]here is no mechanism specific to metaphor, no interesting generalization that applies only to them' (Sperber & Wilson, 2008, p. 84). Since they extend their account to all types of loose language, including approximation and hyperbole, they call their account a *deflationary account* of metaphor. Sperber and Wilson (2008) write that metaphors are often cases of both broadening and narrowing – the ad hoc concept STEEL* in the metaphor *his muscles are steel*, for example, is broader than the encoded concept STEEL because it includes objects not actually made of steel, but also narrower because certain forms of steel, such as melted steel, will not be in the extension of this *ad hoc* concept.

Similes, however, have received less attention from relevance theorists, and a fully-fledged account of simile comprehension has not been proposed. Still, Carston and Wearing (2011) point to a key difference between metaphors and similes, namely that they express different types of propositions, or 'explicatures' in relevance theoretic terms. In the relevance theoretical framework, *explicatures* are propositions that are both (i) expressed by the speaker and (ii) developments of the logical form of the sentence, arrived at through assignment of reference to indexicals and other pragmatic saturation and enrichment (Allott, 2013). While metaphor vehicles will undergo lexical adjustment, simile vehicles will not. So, the simile corresponding

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to example (1), *my best friend is like a comforting blanket*, will be analyzed (on a relevance theoretic account) as expressing the explicature 'MY BEST FRIEND IS LIKE A COMFORTING BLANKET', where the simile vehicle retains its literally encoded referent and we read the utterance as an explicit comparison rather than a category inclusion statement. The claim that simile vehicles and metaphor vehicles have different referents is congruent with Glucksberg and Haught's (2006) class inclusion view of metaphor. To sum up, the Structure Mapping framework (Bowdle & Gentner, 2005; Gentner & Bowdle, 2008) sees the underlying process of similes and novel metaphors as equivalent, whereas the categorization-based views (Wilson & Carston, 2007; Glucksberg & Haught, 2006; Sperber & Wilson, 2008) see metaphors and similes as requiring fundamentally different cognitive processes.

The experimental evidence comparing the processing of metaphors and similes is somewhat inconclusive. Some studies find that metaphors take less time to comprehend than similes (Glucksberg & Haught, 2006; Johnson, 1996; Jones & Estes, 2006), while others find the opposite pattern (Ashby et al., 2018; Bowdle & Gentner, 2005; Gregory & Mergler, 1990). Bowdle and Gentner (2005) argue that these differences have to do with how conventional the metaphors were in each study: Conventional metaphors should be faster to comprehend than their simile counterparts, with the opposite pattern holding for novel metaphors. However, Jones and Estes (2006) did not find such an effect of conventionality on their sample of metaphors and instead argue that the similes in their study took longer to process than the metaphors (Experiment 2) because of the added characters in the word 'like'.

The more direct evidence in this debate comes from Ashby et al. (2018), who conducted an eye-tracking during reading study allowing them to target the processing effort of just the metaphoric vehicle (i.e., without the word 'like'). Across two experiments, they found that metaphors were read more slowly than similes, indicative of an added processing cost. This would be in line with the claims of Bowdle and Gentner (2005), who argue that 'novel figuratives are processed strictly as comparisons' (Bowdle & Gentner, 2005, p. 208), and, as such, novel metaphors would require extra processing effort because they do not have the grammatical form of a comparison. We can argue that the processing difference should appear in the early processing stages, as Ashby et al. (2018) find, because one of the initial processing steps will be to switch from a categorization process to a comparison process (Gentner & Bowdle, 2008).

1.2. How can testing extended metaphors help us understand processing differences between metaphors and similes?

As it stands, the empirical evidence in the debate between categorization and implicit comparison views is inconclusive, with empirical findings providing evidence for or against various aspects of each of the accounts (see Holyoak & Stamenković, 2018, for a comprehensive review). As shown in the previous section, the comparison between the processing effort of metaphors and similes is one arena in which such mixed findings appear. To move the debate on metaphor comprehension forward, Holyoak and Stamenković (2018) recommend looking for empirical evidence from different types of metaphorical constructions in order to evaluate how generalizable the theories are in previously understudied domains. In this regard, we believe that studying the processing differences between single and extended metaphors can

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provide a useful way to approach the study of differences between similes and metaphors. This can, in turn, inform the debate between metaphor comprehension accounts and bring us closer to understanding what cognitive mechanisms are responsible for metaphor comprehension.

Regarding extended metaphors, Carston (2010) posits that they require different processing mechanisms from their single counterparts. Taking the Deflationary Account as a starting point, Carston (2010) argues that while single metaphors fit neatly into the categorization framework (where individual concepts undergo lexical adjustment), extended metaphors work differently. She argues that this type of subsequent *ad hoc* concept creation is too costly (in terms of processing effort) to be a plausible explanation of how we comprehend extended metaphors. Instead of operating via local adjustments to several concepts, extended metaphors require a more reflective or metalinguistic type of processing where we metarepresent the literal meaning of the utterance and sustain it for further processing and inference (Carston, 2010, p. 308). She notes that there is evidence that the literal meaning of words used metaphorically continues to be available, a phenomenon she calls 'the lingering of the literal' (Carston, 2010, p. 305).

Carston, thus, presents a *Dual Processing view* of metaphor where single and extended metaphors require distinct types of processing strategies. A possible way to distinguish between the first and second processing modes is to see the first mode (i.e., the same process as proposed by the Deflationary Account) as a *local* one, and the second mode proposed by the Dual Processing view as a *global* one; lexical modulation involves only local adjustment of individual concepts, whereas the literal form of the whole metaphorical passage forms the basis for inferring the metaphorical meaning of an extended metaphor.

The Dual Processing view has some experimental support (Rubio-Fernández et al., 2016; Ronderos & Falkum, 2023). The first study to explicitly test the Dual Processing view against the Deflationary Account was by Rubio-Fernández et al. (2016). They predicted, based on Carston's view, that extended metaphors should be read faster than single metaphors because they do not require *ad hoc* concept creation and will be initially read as 'literal', with the metaphorical interpretation arising in later stages of interpretation. The results of both a self-paced reading task and an eye-tracking reading experiment were in line with their predictions. Shorter reading times for extended versus single metaphors have also been found in previous studies by Keysar et al. (2000) and Thibodeau and Durgin (2008), who measured reading times for a metaphorical expression that was either preceded by a context sentence containing metaphors from the same conceptual domain or a literal context sentence. Target metaphors preceded by metaphorical contexts were read faster than metaphors preceded by a literal context. These results align with Rubio-Fernández et al.'s (2016) results, although they are not explicit tests of the Dual Processing view.

In a different test of Carston's view, Ronderos and Falkum (2023) used a lexical decision task to investigate the activation levels of literal and metaphor-related features. If extended metaphors do not involve local lexical modulation, but rather are processed through 'metarepresenting' their literal content, literal-related features should have a higher degree of activation during processing of extended metaphors compared to single metaphors. The results of the lexical decision task showed that literal features remained active for longer after participants had read an extended metaphor than after having read a single metaphor, which is in line with the predictions that Ronderos and Falkum (2023) formed based on the Dual Processing

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view. Importantly, Ronderos and Falkum (2023) tested metaphors that were shorter and only preceded by one additional metaphor before the target sentence. This shows that processing differences arise not only in longer and more elaborate extended metaphors but also in metaphors that are 'minimally extended' by just one or two metaphor vehicles.

In sum, various empirical studies (whether explicitly testing Carston's account or not) have shown that metaphors that appear within an extended-metaphoric context are processed differently than when the same vehicles appear as single metaphors (Keysar et al., 2000; Thibodeau & Durgin, 2008; Rubio-Fernández et al., 2016; Ronderos & Falkum, 2023). Critically, this empirical landscape is also compatible with the account that the Structure Mapping view provides of the processing of extended metaphors, known as the Domain Mapping hypothesis (Gentner et al., 2001). The Domain Mapping hypothesis argues that shorter reading times for extended metaphors arise as a result of conceptual priming: The metaphor in the context sentence primes comprehension of the metaphor in the target sentence (Gentner et al., 2001). The Structure Mapping view sees metaphor interpretation as a process of analogical reasoning, where the comprehender maps predicates between the topic and vehicle. As a consequence, additional metaphor vehicles (that are part of the same conceptual domain) will be part of a large-scale mapping process where all the terms that are being used metaphorically contribute to structurally aligning the topic and vehicle domains (Gentner et al., 2001). Since this view states that novel metaphors and similes are processed via the same mechanism (as mentioned in the previous section), it would, thus, be reasonable to assume that embedding a simile in an extended-metaphoric context should yield the same results: The additional simile that draws from the same conceptual domain as the preceding metaphors should benefit from the pre-activated mappings and result in shorter processing time for the resulting 'extended simile' relative to its 'single simile' counterpart. In other words, processing extended similes should require similar reading times to processing extended metaphors.

Categorization theories, on the other hand, are compatible with metaphors and similes being affected differently by a preceding related metaphor because they do not claim that they are processed via the same mechanisms. Comparing the processing of similes and metaphors in an extended-metaphoric context can thus help us move the debate forward by creating a novel environment in which to test the predictions of the different accounts.

This was the motivation for the present study. In an eye-tracking during reading experiment, participants read English sentences containing both metaphors and similes. We collected data on the time it took participants to read the metaphor/simile vehicles in order to draw inferences regarding the processing differences between single and extended metaphors and their simile counterparts. This will bring us closer to understanding whether similes and metaphors are processed via the same mechanisms.

2. Method

2.1. Participants

We tested 39 English speakers between the ages of 18 and 39 (18 males, 21 females), of which five were later excluded for not being monolingual native speakers. As a further

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exclusion criterion, we aimed to remove participants from the analysis who scored lower than 75% accuracy on the comprehension sentences that followed the filler items. No participants were excluded based on this criterion. Participants were recruited through social media and student unions in the greater Oslo area. The sample consisted of both students and non-students and had either normal or corrected-to-normal vision. Participants were given 200 Norwegian crowns for participating in the study (about 20 euros at time of testing) after completion.

2.2. Materials and design

We tested our research questions using an eye-tracking reading paradigm, similarly to Rubio-Fernández et al.'s (2016) second experiment, but with *single similes* and *extended similes* as additional conditions. In our experiment, participants read context and target sentences in each trial, while their eye-movements were recorded.

Our experiment had a 2X2, within-subjects Latin square design with the factors FIGURE (metaphor vs. simile) and CONTEXT (single vs. extended). As dependent measures, we computed first-pass reading times, regression-path duration and total reading times of the vehicle region. *First-pass reading time* refers to all fixations on the region of interest (ROI), that is, the metaphor or simile vehicles, before the gaze exits it, either to the left or to the right of the ROI (Conklin et al., 2018, p. 66). *Regression-path duration* refers to the amount of time the reader spends on the ROI and any preceding parts of the target sentence before moving to the right past the ROI (Conklin et al., 2018, p. 66). *Total reading time* refers to the total amount of time spent reading the ROI. First-pass reading time and regression-path duration have traditionally been referred to as early measures of processing, and regression-path duration has also been argued to reflect intermediate processing stages (Rayner, 1998). Total reading times have been described as indicative of late processing (Rayner, 1998, but see Vasishth et al., 2013, for an alternative view). The ROI in each case was the vehicle region, which was identical across all conditions.

Our items have the same structure as Ronderos and Falkum's (2023) items. Eight of our items are drawn from their study, and eight new ones were constructed for this project. The target sentences in the metaphor conditions had a nominal *A is B* structure, such as *John is a cactus*, where '*a cactus*' represents the critical vehicle region. The target sentences in the simile conditions were identical except that they included the comparison term *like* (e.g., *John is like a cactus.*)

All conditions had two context sentences preceding the target sentence. In the single conditions, the context sentences were literal, making the target sentence the only instance of figurative language in the passage. In the extended conditions, the context sentences contained an instance of metaphorical language, which was related to the metaphor or simile in the target sentence. The notion of 'extended similes' has to our knowledge not been discussed elsewhere and has no established meaning. The way we operationalize the term 'extended simile' is as a simile that appears in a passage with an extended figurative meaning, as is the case for the target sentences in the 'extended simile' condition. Thus, although the figurative content in these passages as a whole is not exclusively made up of similes, the target sentence is still a simile with a figurative meaning which is extended. It is possible to argue that an extended simile should consist only of similes, but for the purposes of this study, we

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Table 1. Example of critical item in all four experimental conditions (metaphor/simile vehicle highlighted)

Condition	Item example
Single metaphor	When Yasmin was writing her first novel, she had a very harsh editor. She often felt discouraged by the critical feedback. His comments were **razors**, and it made writing less fun.
Extended metaphor	When Yasmin was writing her first novel, she had a very harsh editor. She often felt discouraged by the **sharp-edged feedback**. His comments were **razors**, and it made writing less fun.
Single simile	When Yasmin was writing her first novel, she had a very harsh editor. She often felt discouraged by the critical feedback. His comments were like **razors**, and it made writing less fun.
Extended simile	When Yasmin was writing her first novel, she had a very harsh editor. She often felt discouraged by the **sharp-edged feedback**. His comments were like **razors**, and it made writing less fun.

use the term *extended simile* as a short-hand for this particular experimental condition. We chose to keep the contexts in the single and extended conditions identical to increase experimental control and because changing the context in the extended similes to a simile instead of a metaphor would not affect the processing predictions made by the different theories we are testing.

There were 16 critical items and 24 filler items. Table 1 shows the examples of all four critical conditions.

Four of the filler items were metaphors, four were similes, eight were literal, and eight were idioms. The metaphors in the filler items are adapted from Rubio-Fernández (2007) and Jones and Estes (2006). Half of the fillers were followed by a sentence comprehension task where the participant had to indicate whether a statement about the preceding sentences was true or false by clicking either F (false) or J (true). Table 2 shows an example of a filler item with a comprehension sentence.

Because the Structure Mapping View predicts a comparison process specifically for non-conventionalized metaphors, we conducted a norming study to check the conventionality of the items. Twenty-one participants were asked to rate the conventionality of the metaphors on a scale from 0 to 100, where 0 indicated 'not familiar at all' and 100 indicated 'very highly familiar'. We also conducted a norming study for aptness, that is, how well the metaphors express their non-literal meaning. Following Blasko and Connine (1993), we asked 30 participants to rate how well the metaphors express their non-literal meaning on a scale from 0 to 100, 0 representing 'not well at all' and 100 representing 'perfectly well'. The mean, median, range and standard deviation (SD) are reported in Table 3.

Table 2. Example filler and sentence comprehension task

Filler item	Comprehension sentence
Michelle accidentally shrunk Muhammad's sweater while doing laundry. It was his favorite, and he wore it all the time. She was very sorry, and she felt terrible.	Michelle did Mohammad's laundry.

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Table 3. Scores for conventionality and aptness

Metaphor property	Mean	Median	SD	Lowest score	Highest score
Conventionality	60.9	72.0	32.9	00.0	99.0
Aptness	75.5	84.5	26.2	00.0	99.0

2.3. Procedure

The data were collected using an Eyelink 1000+ eye-tracker developed by SR Research. The eye-tracker was calibrated to the participant's right eye using a 9-point grid. Only calibrations with a maximal error lower than or equal to 0.5 were accepted.

Participants were instructed to read the sentences on the screen at a normal pace while also making sure that they understood the sentences before moving on to the next sentence. They were further instructed to keep their thumbs on the spacebar, their left index finger on the F-key and their right index finger on the J-key throughout the entire experiment. For each trial, participants first saw the context sentences on the screen. After reading the context sentences, they pressed the spacebar to move on. They then saw the target sentence and pressed the spacebar again after having read and understood it. The context sentences disappeared from the screen when the target sentence appeared. Half of the filler items were followed by a sentence comprehension task where the participant had to indicate whether a statement about the previous sentence was true (by pressing J) or false (by pressing F). The test session lasted for about 20 minutes. Participants were offered a break after half of the items were completed.

2.4. Predictions

Our predictions are based on previous findings on extended metaphors and on the processing of similes versus metaphors, as well as on our interpretation of categorization and comparison accounts of metaphor comprehension. First, based on the results of Ashby et al. (2018), we predicted a main effect of FIGURE (metaphor vs. simile), where similes should be read faster than metaphors. Second, based on the literature on extended metaphors, we predicted that metaphors appearing in an extended context (i.e., the 'extended metaphor' condition) should be read faster than the same metaphors when they appear in the absence of such a context (i.e., the 'single metaphor' condition). If metaphors and similes are processed via different cognitive mechanisms, we would expect the pattern to differ for the simile conditions. This would result in a predicted interaction effect between FIGURE (metaphor vs. simile) and CONTEXT (single vs. extended). Alternatively, if metaphors and similes are processed via the same mechanism (as predicted by comparison accounts), the extended-metaphoric context should have an identical effect on both figures, with no interaction between the two factors to be expected.

We also make more precise predictions derived from the theoretical accounts regarding our three dependent measures (first-pass reading times, regression-path duration, total reading times). Regarding our first prediction, consider that the Structure Mapping framework (Bowdle & Gentner, 2005; Gentner & Bowdle, 2008) states that novel figurative utterances will be easier to understand if

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expressed as similes than as metaphors because metaphors require the listener to go from a categorization process to a comparison process instead of directly accessing the comparison. Consequently, the theory would predict any processing advantage of similes versus metaphors to be visible during early processing stages. This should result in differences being visible already during first-pass reading time.

Regarding our second prediction (interaction between the factors CONTEXT and FIGURE), shorter reading times for extended metaphors compared to single metaphors may be explained not only by a more literal processing mode as suggested by Carston (2010) but also by the Domain Mapping hypothesis. If the Domain Mapping hypothesis is correct and faster reading times are driven by priming, we should see numerically faster reading times in early measures. This is because the facilitation effect of priming from the preceding metaphor vehicles should affect the initial stages of processing where the hearer is matching predicates between the topic and vehicle.

What would Carston's view predict for late and early processing measures? Carston (2010, p. 308) writes that the switch from the lexical adjustment mode should happen when local lexical modulation becomes too effortful relative to the high accessibility of the literal meaning. Rubio-Fernández et al. (2016) interpret this as meaning that processing differences between single and extended metaphors should be visible in early processing measures as extended metaphors are initially read as literal, while single metaphors are not. Their study, however, describes what would happen when the participant reads a part of an extended metaphor only after the switch has already happened, as their items contain many cases of metaphorical language before the target sentence. In our items, on the other hand, the target metaphor is (in all cases but two) preceded by only one metaphor. This means that if our items trigger a switch in a processing mode, this would happen as the reader encounters our region of interest, and the switch itself should be captured in the eye-tracking measures. In this case, potential processing differences may be captured by later measures only (such as total reading times), since the participant presumably starts in the first mode and then switches only after they have started reading the metaphor vehicle.

Finally, if the mechanisms behind simile comprehension are different, there is no reason to expect there to be a processing advantage for the extended simile condition relative to single similes. In Carston's account, the processing differences for extended metaphors are a result of switching from the local lexical adjustment mode to the literal metarepresentational mode. Since similes do not require local lexical adjustments in the first place and are always processed as comparisons, there would be no need to switch processing mode, which should result in comparable processing measures. Alternatively, as the Domain Mapping hypothesis suggests that processing advantages for extended metaphors come from conceptually priming the target domains, we would expect the similes to also be subject to this priming effect, which would result in shorter reading times for the extended simile condition compared to single similes, akin to what we would expect for metaphors. This would then bring about a main effect of CONTEXT and no interaction between CONTEXT and FIGURE. An overview of the different theoretical positions and their predictions can be seen in Table 4. Table 5 provides an overview of eye-tracking measures.

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Table 4. Theoretical positions and their predictions

Theory	Predictions
Comparison views	Not compatible with only metaphors being read faster in the extended-metaphoric context. The extended-metaphoric context will cause a priming effect for both metaphors and similes.
Categorization views	Compatible with only metaphors being read faster in the extended-metaphoric context. Similes and metaphors processed by different mechanisms.
Dual Processing View	Compatible with only metaphors being read faster in the extended-metaphoric context. Extended metaphors trigger a different processing mechanism.

Table 5. Explanation of eye-tracking measures

Eye-tracking measure	Data measured	Processing stage
First-pass reading time	All fixations on region of interest (ROI) before gaze exits either to the left or to the right.	Early
Regression-path duration	The amount of time the reader spends on the ROI, and any preceding parts of the target sentence before moving to the right past the ROI.	Early/intermediate
Total reading time	The total amount of time spent reading the ROI.	Late

2.5. Analysis

We tested our predictions by analyzing reading times of the metaphor and simile vehicles (i.e., *razors* in the example item given in Table 1). To analyze the data, we fitted three 'maximal' mixed-effects linear models (Barr et al., 2013) to the log-transformed reading times of each of the three reading times measured for the critical vehicle region. The reading times were all log-transformed following the results of a box-cox test (Box & Cox, 1964), given that the residuals of an intercept-only model were not normally distributed. Each of the three models had the factors FIGURE and CONTEXT as predictors, as well as their interaction and the continuous predictor TRIAL INDEX (as a covariate). FIGURE and CONTEXT were both sum-contrast coded. The models also included random intercepts by items and by participants, as well as random slopes for both factors and their interaction by items and by participants. All models excluded the random correlations between intercepts and slopes. We used the Satterthwaite approximation to compute p-values for the individual coefficients. Considering how the three dependent measures (first-pass reading times, regression-path duration and total reading times) are correlated, we corrected the p-values for multiple comparisons using the Bonferroni correction to reduce the false positive rate (von der Malsburg & Angele, 2017). As a consequence, we set our threshold for assessing statistical significance at 0.016. The syntax for our regression model (in R) was $log(RT) \sim context*type + TRIAL_INDEX + (1 + context*type|item) + (1 + context*type|participant)$

The analysis was run in R (R Core Team, 2020) and RStudio (RStudio Team, 2020) using the Tidyverse (Wickham et al., 2019), here (Müller & Bryan, 2020), MASS

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(Ripley et al., 2023), Rmisc (Hope, 2022), lmerTest (Kuznetsova et al., 2017), afex (Singmann et al., 2023) and lme4 (Bates et al., 2015) packages.

2.6. Results

All results, data and analysis scripts can be found on the project's OSF repository, together with a complete list of the sentences used as experimental materials: https://osf.io/wvgpt/. The output of the models for the three reading measures is shown in Tables 6, 7, and 8, and all reading times can be seen in Figure 1. As seen in Table 6, the model fitted on first-pass reading times did not bring about any significant effects of either one of our factors or their interaction. In regression-path duration, we found a main effect of FIGURE (metaphor vs. simile), suggesting that the vehicles were likely read more slowly in the case of metaphors compared to similes. However, this effect was not significant under the Bonferroni-corrected alpha threshold of 0.016. No other significant results were found for regression-path duration. Finally, in total reading times, there was a significant effect of FIGURE, suggesting that participants spent overall less time reading the vehicle region for similes relative to metaphors. Critically, in total reading times, we additionally found an interaction effect of

Table 6. Linear regression model of first-pass reading times

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
CONTEXT	−0.03	[−0.11, 0.04]	−0.82	31.43	.421
FIGURE	0.05	[−0.02, 0.12]	1.51	417.17	.132
TRIAL INDEX	0.00	[−0.01, 0.00]	−1.14	458.39	.254
CONTEXT* FIGURE Interaction	−0.03	[−0.18, 0.12]	−0.36	16.88	.721

Note: Model used a sum-contrast coding scheme. RTs were log-transformed. Alpha-threshold was set to 0.016 after Bonferroni correction.

Table 7. Linear regression model of regression-path duration

Term	$\widehat{\beta}$	95% CI	*t*	*df*	*p*
CONTEXT	−0.02	[−0.10, 0.06]	−0.49	15.13	.633
FIGURE	0.10	[0.02, 0.18]	2.43	14.67	.028
TRIAL INDEX	0.00	[−0.01, 0.00]	−2.18	452.78	.030
CONTEXT* FIGURE Interaction	−0.01	[−0.16, 0.14]	−0.09	31.06	.926

Note: Model used a sum-contrast coding scheme. RTs were log-transformed. Alpha-threshold was set to 0.016 after Bonferroni correction.

Table 8. Linear regression model of total reading times

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
CONTEXT	0.00	[−0.08, 0.07]	−0.04	457.14	.971
FIGURE	0.16	[0.09, 0.24]	4.23	457.57	< .001
TRIAL INDEX	−0.01	[−0.01, −0.01]	−4.67	458.89	< .001
CONTEXT* FIGURE Interaction	−0.21	[−0.36, −0.06]	−2.70	456.92	.007

Note: Model used a sum-contrast coding scheme. RTs were log-transformed. Alpha-threshold was set to 0.016 after Bonferroni correction.

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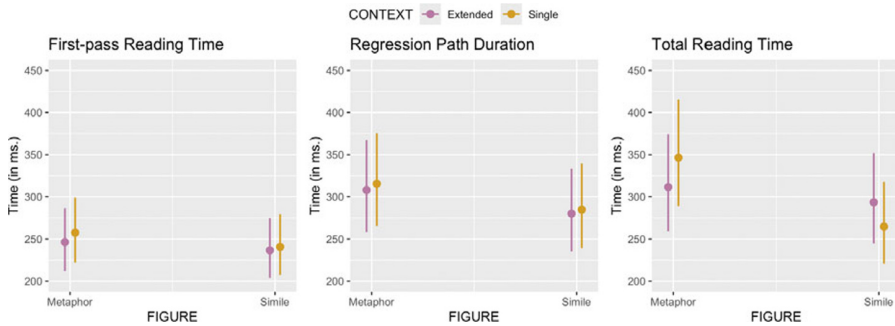


Figure 1. Regression models.
Note: Marginal effects of the regression models of first-pass reading time, regression-path duration and total reading time. Dependent variables were back-transformed to milliseconds for visualization only. Error bars denote 95% confidence intervals.

FIGURE (metaphor vs. simile) and CONTEXT (single vs. extended). Extended metaphors were numerically read faster than single metaphors, whereas the difference appeared to go in the opposite direction for single similes and the extended simile condition. To probe the nature of this interaction, we conducted a subsequent pairwise comparison, as implemented in the R package *emmeans* (Lenth et al., 2024). This showed no significant difference in total reading times between single and extended metaphors as well as no significant difference between single and extended similes after correcting the p-value for multiple comparisons.

We included the conventionality scores from the norming task as covariate in our model to check if the level of conventionality had any effects on our results. Including conventionality as a covariate did not affect the results. Two of the metaphors scored higher than 80 in the conventionality task. Removing these items from the analysis also had no effect on the results.

3. Discussion

The current experiment presents a novel test of the processing differences between metaphors and similes by investigating reading times of the figures in single and extended-metaphoric contexts. First, following the literature on extended metaphors (e.g., Keysar et al., 2000; Ronderos & Falkum, 2023; Rubio-Fernández et al., 2016; Thibodeau & Durgin, 2008), we predicted that we would find a difference in reading times of the metaphor vehicles in the target sentences of the single and extended metaphors, with metaphors being read more slowly when they appear in single relative to extended-metaphoric contexts. Additionally, we predicted that if metaphors and similes are processed via different mechanisms, this pattern should not hold for similes. Overall, this was predicted to result in an interaction of our two experimental factors, CONTEXT and FIGURE. Alternatively, if similes and metaphors are processed via identical mechanisms, they should behave similarly in extended-metaphoric contexts and bring about the same reading pattern. Finally, in line with previous eye-tracking results from Ashby et al. (2018), we predicted that metaphor vehicles would in general be read more slowly than simile vehicles.

Our results show that simile vehicles were read overall faster than metaphor vehicles and that embedding the vehicle in an extended-metaphoric setting had a

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different effect on metaphors than it did on similes. The main effect of FIGURE (simile vs. metaphor) – showing shorter reading times for similes relative to metaphors – was only significant in total reading times, and there were no significant differences between metaphors and similes in first-pass reading time or regression-path duration. Total reading time is typically seen as a measure of late processing stages. This means that the effect we found is inconsistent with what would be predicted by the Structure Mapping view, according to which the processing advantage for similes should arise during early stages of processing. However, the absence of a significant difference in first-pass reading time between metaphors and similes is not straightforwardly interpretable: The results pattern numerically with those found in later reading measures, so it could be that we simply did not have enough statistical power to capture an underlying true effect. Alternatively, it could be that differences between metaphors and similes truly only arise in later stages, contra the Structure Mapping view. In contrast to our finding, Ashby et al. (2018) report processing differences between metaphors and similes only in early processing measures. One reason for the difference in findings could be that the items in our study were more novel than the ones Ashby et al. (2018) tested. Because their items were quite conventional, it could be the case that their figurative meaning is more available, making it easier to integrate the metaphor vehicle in its linguistic context, and that this early integration brings about an early integration cost.

The found interaction effect indicates that metaphors and similes were affected differently by appearing as part of a passage with an extended figurative meaning. This finding can be accounted for by categorization views: Glucksberg and Haught (2006), for example, argue that metaphors and similes are entirely different, often result in different interpretations and rely on separate mechanisms. It would, therefore, not come as a surprise that extended-metaphoric contexts modulate processing effort of the two figures in different ways. Comparison views (such as Gentner's Structure Mapping account), on the other hand, would struggle to accommodate these findings. If novel metaphors necessarily need to be understood via comparison (as do similes), one would expect the extended-metaphoric context to interact with similes and metaphors in the same way, that is, that the single versus extended similes should have a similar processing pattern to single versus extended metaphors where the extended condition is read faster. The account would, therefore, need to posit additional linking hypotheses to explain why extended metaphors should work differently with similes.

Despite the found interaction, follow-up pairwise comparisons did not reveal any simple effects between single and extended metaphors, on the one hand, and single and extended similes, on the other. However, numerically, the results do pattern with what would be predicted by the literature, with single metaphors taking more time to read than extended metaphors. This would be as predicted by both the Structure Mapping view (which attributes the difference to conceptual priming from preceding metaphor vehicles; Gentner et al., 2001) and Carston's dual-route approach (which posits qualitatively different comprehension strategies for single and extended metaphors). Similes, however, did not pattern in this way, with extended similes taking numerically longer to process than single similes. If, following the Structure Mapping view, both similes and metaphors preceded by a related metaphor are part of large-scale conceptual mappings, the extended conditions should display the same facilitation effect for both similes and metaphors, which is contrary to what we found in this study. The lack of similar processing patterns in metaphors and similes is

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compatible both with Carston's (2010) proposal of two qualitatively different processing modes in metaphor comprehension and with the more general relevance theoretic view of what types of explicatures, or propositions, metaphors and similes express.

When it comes to the main effect of similes being read faster than metaphors, a possible relevance theoretic explanation is that the comparison term 'like' signals to the reader that what follows is a comparison, and that the reader's expectation of relevance is satisfied once one or a few salient similarities between the topic and vehicle have been detected, while the non-literal form of the metaphor suggests that there are a wider range of more weakly communicated possible interpretations. This way of accounting for the main effect is congruent with the categorization view we have argued is compatible with our interaction effect. A similar explanation has been offered by Noveck et al. (2001) for the relatively larger processing effort for metaphors compared to literal statements. They argue, in relevance theoretic terms, that if metaphors bring extra cognitive effects, they should also be accompanied by extra cognitive effort (but see Carston and Yan (2023) for a full-length discussion of how Noveck et al.'s (2001) finding may be attributed to referentiality).

It is important to mention the various limitations to our study. First, the experiment could benefit from a larger sample. This study tested as many participants as was possible with the available resources, but future studies should aim for better power analysis heuristics in order to be able to better interpret the patterns in the data. Second, our study cannot, on its own, provide direct evidence on the cognitive mechanisms that are involved in the processing of metaphors and similes. It does, however, shed light on whether the processes are the same or not, which in turn relates to predictions made by theories that claim that different mechanisms are at play. As such, our study can be seen as providing indirect evidence for the mechanisms involved, with the data being easier to account for by categorization views of metaphor comprehension as opposed to comparison accounts. In a subsequent step, it will be important to look at exactly how their processing is different, probing the nature of the different processing strategies. Third, although we have predicted shorter reading times for extended metaphors, the Dual Processing view can also be interpreted to predict the opposite. We predicted shorter reading times because Carston (2010) writes that the second mode involves reading the passage as literal initially. However, Carston (2010) also writes that the second mode is more 'reflective', which means that it is also possible to argue that processing extended metaphor would in fact lead to a slow-down in reading. Regardless of whether extended metaphors on this view should lead to longer or shorter reading times, the differences found in this study, in combination with the results of Rubio-Fernández et al. (2016) and Ronderos and Falkum (2023), do suggest that there are qualitatively different types of processes involved in the two metaphor types.

4. Conclusion

This study examined the processing differences between both similes and metaphors and single and extended metaphors by seeing if extension of figurative meaning has the same effect on the two figures of speech. The results of an eye-tracking during reading experiment showed that extending the figurative utterance yielded an overall different pattern in reading times for metaphors and similes, as indexed by an

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interaction effect. We interpret this pattern as suggesting two things: first, metaphors and similes employ different cognitive mechanisms. If not, they should be affected in the same way when their figurative meaning is extended. We see this as being more in line with Categorization views of metaphor processing than with Comparison views. Second, the processing differences between single and extended metaphors that have been observed in this study, as well as several previous studies, are of a qualitative rather than quantitative nature. If the extended metaphors are read faster due to priming effects, this effect should also be found in the simile conditions. We interpret this as supporting Carston's (2010) view that single and extended metaphors require different processing modes.

Data availability statement. The data that support the findings of this study are openly available in Open Science Framework in the following link: https://osf.io/wvgpt/.

Competing interests. The authors declare none.

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