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A metaphor is not like a simile: reading-time evidence for distinct interpretations for negated tropes

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ABSTRACT

Studies have suggested that metaphors (*Lawyers are sharks*) and similes (*Lawyers are like sharks*) have distinct representations: metaphors engender more figurative and abstract properties, whereas similes engender more literal properties. We investigated to what extent access to such representations occurs automatically, during on-line reading. In particular, we examined whether similes convey a more literal meaning by following the metaphors and similes with explanations that expressed either a figurative (*dangerous*) or a literal property (*fish*) of the vehicle. In a self-paced reading with a moving window paradigm, we presented participants with negated simile and metaphor main clauses (*Lawyers are not* (*like*) *sharks*) followed by explanations that also negated either a figurative (*because lawyers are not dangerous*) or a literal property of the vehicle (*because lawyers are not fish*). We found that vehicles (*sharks*) in metaphors were read significantly faster than those in similes. In addition, explanations negating a figurative property were read faster after metaphors, whereas explanations negating a literal property were read faster after similes. These results support the hypothesis that metaphors and similes rely on different interpretive processes, suggesting that similes access literal representations while metaphor access figurative ones in real time.

The temptation to consider metaphors and similes as analogous forms of expression has been around at least since the days of Aristotle (1926), who thought copular metaphors (e.g., *Life is a journey*) might exist only as abbreviated similes (e.g., *Life is like a journey*). This idea was carried forward in more contemporary metaphor processing theories (e.g., Miller, 1979), on the assumption that the interpretation of a particular metaphor requires understanding the expression as a comparative (i.e., simile) form. Earlier versions of categorization and career of metaphor theory have also argued for equivalence between metaphor and simile expressions; the former suggesting that similes were understood as metaphors (Glucksberg & Keysar, 1990), and the latter suggesting that metaphors were understood as similes (Gentner & Wolff, 1997). Along the same lines, it has also been proposed that metaphors are simply exaggerated similes (e.g., Barnden, 2014). In their current forms, however, these theories now recognize what has become the prevailing argument: metaphors and similes are distinct (for discussions on how metaphors are *not* like similes, see, e.g., Barnden, 2012; de Almeida, Manouilidou, Roncero, & Riven, 2010; Haught, 2013, 2014; O'Donoghue, 2009). Metaphors and similes are used for different purposes in texts (Romano, 2017) and are processed differently to the point that they engage distinct brain areas (Shibata et al., 2012) or yield distinct eye-movement patterns (e.g., Ashby, Roncero, de Almeida, &

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Agauas, 2018). For example, similes are used more often to provide a novel relationship (Roncero, Kennedy, & Smyth, 2006), or to be humorous, (Roberts & Kreuz, 1994; Veale, 2013).

The differences found for metaphors and similes might reflect their distinct structures. Whereas the overt *like* in similes (*X is like Y*) forces the reader/listener to initiate a comparison between the topic (e.g., *life*) and the vehicle (e.g., *journey*) terms, the metaphor has the form of a categorization or predication statement (*X is Y*). For this reason, it can be argued that similes can be more difficult to comprehend because they may require exhaustively comparing various attributes, and subsequently considering which properties would be most relevant for the presented comparison.[1] But if they are distinct forms, are their distinct semantic representations computed in real time? Interestingly, there have only been a handful of studies comparing comprehension latencies for metaphor and simile expressions, with mixed results. For example, Gregory and Mergler (1990), Shibata et al. (2012), Ashby et al. (2018), and Durgin and Gelpi (2017) reported that participants required more reading time for metaphors compared to similes, whereas Johnson (1996) reported that similes took longer, and Chiappe, Kennedy, and Chiappe (2003) and Jones and Estes (2006) reported no reading times differences between the two types of expressions. In the present paper, we discuss the limitations inherent to these past studies and why a novel paradigm is needed for assessing how metaphors and similes are processed. We then present a study that aims to remedy these limitations by employing a self-paced moving-window paradigm that presents sentences in a negative structure to assess whether metaphor and similes produce similar semantic interpretations.

The representation and processing of metaphors and similes

Researchers generally agree that the way a simile or metaphor will be interpreted depends on the status of the vehicle. For example, career of metaphor theory (Bowdle & Gentner, 2005; Gentner & Bowdle, 2008) predicts novel metaphors (e.g., *Life is a bottle*) to cause initial comprehension problems because the vehicle term (*bottle*) lacks an associated figurative meaning that can be projected onto the topic. The proposed solution is to understand such statements as similes (i.e., *Life is like a bottle*) which then triggers a process of feature matching and projection between the topic and vehicle. This way, the novel expression is understood as an analogy; for example, *Life is like a bottle because both can be filled up*. Over time, as the vehicle's career progresses from being used in multiple statements with various topic terms, an associated conventional figurative meaning is created and stored in memory. At this point in the vehicle's career, this theory predicts that metaphorical statements no longer need to be understood as comparisons, and can instead be understood as categorical statements directly because it is now possible to retrieve an associated figurative meaning from memory and project that meaning onto the topic. Crucially, however, conventionalization is argued to reflect a shift from comparative processing to categorical processing: "because metaphoric categories are created as a by-product of figurative comparisons, they do not affect the interpretation of these comparisons" (Bowdle & Gentner, 2005, p. 198). Thus, the categorization process proposed by career of metaphor theory for metaphors with conventional vehicles is ultimately a cognitive "shortcut". To use an analogy, the first time a child learns that 3 times 6 equals 18, it is a relatively laborious cognitive process compared to the eventual point in which the child can simply retrieve the associated answer from memory. Career of metaphor theory is ultimately proposing a similar progression for metaphor interpretation: at first, a more laborious comparative process is needed to obtain the associated figurative meaning, but with use, the comparative process is no longer needed, nor employed, because the associated meaning can instead be retrieved directly from semantic memory.

In contrast, categorization theory, as articulated by Glucksberg and Haught (2006), predicts that the vehicle term in metaphors and similes is different, such that *shark* refers to the figurative referent of

[1]Throughout this paper we use "properties" or "attributes" rather loosely referring to the kinds of semantic content that might be accessed upon tokening a particular word or expression, without committing ourselves to the idea that these properties are *constituents* of semantic representations. We return to this issue in the General Discussion.

shark in the metaphor *Lawyers are sharks*, but to the literal referent of *shark* in the simile *Lawyers are like sharks*. Thus, when vehicles in similes are understood via comparison processing, they are thought to bring to mind more concrete/literal properties (e.g., *shiny* for *Ideas are like diamonds*) that reflect more physical aspects; whereas vehicles in metaphors are understood through categorical/predicative processing, which brings to mind more abstract and superordinate qualities of the vehicle (e.g., *insightful* for *Ideas are diamonds*). Haught (2013) found further support for the argument that vehicles activate different semantic representations by creating expressions with complex adjective-vehicle compounds (e.g., *well-paid*) whose adjectives were applicable to either the topic, vehicle, or both. Participants were found to read metaphors faster than similes when the adjectives were applicable only to the topic (e.g., *My lawyer is a well-paid shark* vs. *My lawyer is like a well-paid shark*). Haught argued that participants found the simile form more difficult because the vehicle in similes referred to an entity that did not exist as a vehicle (i.e., a literal shark that is well-paid) whereas metaphors referred to an abstract superordinate category that projects properties to the topic (well-paid lawyer).

Other researchers have predicted that equal or different reading times will depend on additional item variables. For example, Bowdle and Gentner (2005) suggested that comprehension latencies are related to the conventionality level of experimental items, such that novel figurative vehicles are read faster as similes, but conventional vehicles are read faster as metaphors. In line with this hypothesis, an eye-tracking study conducted by Ashby et al. (2018) found that highly familiar metaphors are read as quickly as similes, but unfamiliar metaphors take longer to read than similes with the same constituents. However, this familiarity effect was found only in re-reading measures, not during first-pass reading of the expressions. In contrast, Glucksberg and Haught (2006) argue that aptness (how well a vehicle term captures properties of the topic), rather than familiarity, will predict ease of comprehension, with more apt expressions requiring less processing time. In a pivotal study, Jones and Estes (2006) compared aptness and conventionality as a predictor of metaphor reading times. Specifically, they compared metaphors with the same vehicle, but different topics. They reasoned that aptness is a function of both topic and vehicle combination, while conventionality is more dependent on the figurative interpretation of the vehicle alone and the properties it attributes to the topic. In this manner, a given vehicle (e.g., *fossil*) had the same figurative meaning to attribute to a particular topic, but the property that this vehicle is supposed to predicate of the vehicle (e.g., *old*) was more aptly applicable to one topic (*senator*; as in *The senator is a fossil*; apt metaphor) than the other (*track star*; as in *The track star is a fossil*; less apt metaphor). Jones and Estes found that aptness, rather than conventionality (the strength of a vehicle's associated figurative meaning), was a stronger predictor of participants' comprehension times. Indeed, numerous studies have also produced results suggesting that aptness is a better predictor of comprehension ease than conventionality or familiarity (e.g., Chiappe et al., 2003; Glucksberg & Haught, 2006; Haught, 2013; Roncero & de Almeida, 2014, 2015; but see Bowdle&Gentner, 2005).

Although these results are interesting, a critical limitation of studies examining the interpretation of metaphors and similes has been the experimental paradigms employed, which involve asking participants for an interpretation, or to press a button, once they believed they comprehended a sentence (e.g., Chiappe et al., 2003; Jones & Estes, 2006; Shibata et al., 2012). These decisions effectively reflect both the time needed to read an expression plus the time needed to confidently judge that comprehension has been adequately reached. It is possible that similes require more time to evaluate when comprehension has been reached, even after the initial comparative processing is finished. Moreover, these overt judgments are subject to many factors beyond those necessary for attaining representations for the expressions – what Pylyshyn (1984) called "cognitive penetrability": in this case, when the processing operations that the comprehender engages are modified according to goals or expectations imposed by the task. In order to understand the mechanisms underlying the comprehension of metaphor and simile processing – and thus whether or not one form is more complex than the other – there is a need for an online, real-time processing comparison between the expressions.

The need for online experimental data can be observed when we further consider studies examining interpretation differences between metaphors and similes. Akin to processing studies, interpretation

studies to date have been limited by a reliance on offline measures where multiple extraneous variables could have affected the reported interpretations. For example, both Chiappe and Kennedy (2000), as well as Roncero and de Almeida (2015) compared the interpretations of metaphors and similes by instructing participants to list the properties that first came to mind when participants read metaphor and simile statements. Both studies found that participants provided similar property lists, inconsistent with the categorization theory prediction that metaphors and similes would activate different semantic representations. Indeed, when we (Roncero & de Almeida, 2015) compared the overall literalness of the properties listed for all 84 topic-vehicle pairs, we found them to be similar for both metaphors and similes. In that study, however, participants were encouraged to write at least three properties for each expression read, and this may have wiped out the initial semantic representations produced by reading the distinct metaphor and simile forms. Along the same lines, in Haught's (2013) study, there was no difference between similes and metaphor comprehension reading times when the added adjective applied only to the vehicle or equally to the topic and vehicle (e.g., *My lawyer is a vicious shark* vs. *My lawyer is like a vicious shark*). However, if the very process of evaluating the vehicle as a literal or figurative entity is automatic, it would be incorrect to conclude from these equivalent processing times that metaphors and similes failed to activate different semantic representations in the "vicious" condition in contrast to the "well-paid" condition, discussed above. Instead, it could be argued that participants in the "vicious" condition, despite the similar comprehension times, also attained distinct representations. We note these results here to demonstrate that while a difference in one condition is used to support the argument that metaphors and similes access distinct representations, there are alternative conditions where similar reading times, and even similar property lists, nevertheless appear. Most lacking is a study specifically examining to what extent metaphors and similes automatically access distinct representations.

A novel paradigm for contrasting metaphors and similes

As discussed above, studies have shown strong evidence that similes and metaphors are both processed and interpreted differently, but most studies have relied on offline methods that could have introduced extraneous variables, potentially influencing the results. To our knowledge, only a few studies have employed more sensitive time-course measures comparing metaphors directly with similes – two employed eye-tracking (Ashby et al., 2018; Durgin & Gelpi, 2017) and one employed a cross-modal lexical priming technique (Patalas & de Almeida, 2019). More directly related to the present study are the two eye-tracking studies. They both demonstrated that there are processing differences between metaphors and similes, with metaphors taking *longer* than similes. Both studies also argue that the extra time taken by the metaphor reflects different semantic/pragmatic processes of interpretation, and both suggest that this may be due to the time taken to access the alternative figurative content at the time the vehicle is accessed. While these studies have shown differences between the two expressions, they have not provided direct evidence for what underlies the greater reading times for metaphors.

We designed the present study with two goals in mind: (1) to verify whether metaphors and similes access distinct semantic representations; and (2) to investigate the automatic online meaning computations produced before more conscious executive processes take place – or at least, before participants could consciously reflect upon the properties accessed by the expressions. Toward these goals, we employed two key manipulations. First, we had participants read metaphors and similes in a word-by-word self-paced reading paradigm in the form of a moving window. Using a moving-window paradigm – which is a more sensitive measure than the omnibus response times employed by other studies – allowed us to compare the reading times of metaphors and similes specifically at the vehicle position, where the properties attributable to the topic are presumably accessed. This method also addresses the sentence length problem whereby reading times for similes may be longer due to the extra word "like." Based on previous arguments suggesting that comparative processing (simile) should be more difficult than predicative/categorical processing (metaphor),we predicted that simile vehicles would yield slower reading times in comparison to metaphor vehicles. Alternatively, based on

the two eye-tracking studies mentioned above, it is possible that metaphors take longer than similes because the literal interpretation of the vehicle needs to access its metaphorical content, contrary to the vehicle in the simile expression, which is taken literally (see Ashby et al., 2018; Durgin & Gelpi, 2017). Following Glucksberg and Haught (2006) arguments, we expected that the sentence with the figurative property would be read faster after a metaphor because the metaphor form would prime a salient figurative property. In contrast, if the vehicle is interpreted literally in similes, then explanations with the literal property should be read faster after similes.

Apotential problem, however, is that explanations containing the literal property could be read slower because the statements themselves are objectively false. Since lawyers are not literally fish, for example, reading the sentence *Lawyers are (like) sharks because lawyers are fish* could cause confusion and slow reading times more so than statements that assert a related figurative property – such as *Lawyers are (like) sharks because lawyers are dangerous*. To avoid this potential confound, we introduced a second key manipulation in the present study: presenting metaphors and equivalent similes in negated form (e.g., *Education is not (like) a tree*) followed by negated explanations (e.g., . . . *because education does not grow*). These explanations reflected (in fact, negated) either a figurative property of the expression (*Education is not (like) a tree because education doesn't grow*), or highlighted the vehicle as a literal entity by referring to (also negating) a literal property (*Education is not (like) a tree because education is not a plant*).[2] In this manner, both sentences can be seen as being objectively true as lawyers are not literally fish, and on a matter of opinion, people may deem lawyers as not dangerous.

Writing our statements in a negated form also allowed us to examine questions related to comprehending a negated figurative statement. Logical negation involves necessarily the opposite truth value of an affirmative statement, although this might not be the case when we are dealing with psychological processes. For example, it has been argued that understanding a negated statement first requires processing that statement as an affirmative one, which leads to longer reading times due to the later application of the negation operator (e.g., Hasson & Glucksberg, 2006; He et al., 2018; MacDonald & Just, 1989; Maciuszek & Polczyk, 2017; Mayo, Schul, & Burnstein, 2004; Van Weelden, Schelperoord, & Maes, 2017). The schema-plus-tag model (Clark & Chase, 1972), for instance, proposes that negative statements of the form *A is not B* are understood by representing the proposition as *[NOT [A is B]]*. Consequently, understanding a negated sentence is assumed to take longer than understanding an affirmative sentence because two steps are required for comprehension: processing the positive core proposition, followed by negating that same core. In contrast, a statement of the form *A is B* would be expected to have shorter reading times because it is interpreted directly as *[A is B]*. For example, when people read the statement *Lawyers are sharks*, they would be expected to only entertain the assertion with, perhaps, an interpretation such as "lawyers are dangerous". However, when reading the negated statement *Lawyers are not sharks*, by hypothesis people would mentally represent both the negated statement, as well as its affirmation (i.e., *Lawyers are sharks*). Accordingly, the need to mentally represent both statements – or the very process of applying the negation operator – would result in longer reading times.

Support for these predictions comes from a study by Hasson and Glucksberg (2006). They found that affirmative metaphors (e.g., *My daughter is an angel*) primed affirmative-related properties (*sweet*), but not negated-related properties (*nasty*), in a lexical decision task. However, negated metaphors (*My daughter is no angel*) primed both affirmative- and negated-related properties at 500 ms after the presentation of the metaphor. They also found that, at 150 ms after the presentation of a negated metaphor, the priming effect was actually stronger for the affirmative-related properties, whereas at 1000 ms after, a priming effect was only found for the negative-related properties. Further support for this effect comes from studies employing visual metaphors: Van Weelden et al. (2017) found that verification latencies were shorter for similes in the form of *X is not like Y* (e.g., *A forklift is*

[2]Notice that, although what we call "figurative property" can also be used as a literal property, we refer to them as figurative because they also apply to the vehicle in the figurative sense (e.g., education leads to mental growth; music can be addictive; see Roncero & de Almeida, 2015, for exensive norms on these materials).

not like an elephant) when participants previously viewed two similarly shaped representations of two objects (an elephant similarly positioned as a forklift), rather than two dissimilarly shaped representations (an elephant in a different shape compared to a forklift), suggesting that the statement was easier to process when participants first saw the two objects as similar. These results are consistent with the argument that people comprehend affirmative statements directly, whereas negative statements are understood by first interpreting the negated statement as an affirmative one, followed by subsequently negating this propositional core.

The present study

Using a self-paced reading moving window paradigm, we contrasted the vehicle and explanation reading times of the expressions and manipulated the base metaphor and similes sentences in two manners. First, we presented the expressions in a negated form (e.g., *Lawyers are not (like) sharks*). Second, we followed the main clause with an explanation clause that stated either a salient figurative property of the vehicle or made reference to one of the vehicle's literal properties. We expected vehicles in negated similes to have longer reading times because they are, by hypothesis, understood as comparative statements rather than categorizations. Explanations containing a figurative property (*Lawyers are not sharks because lawyers are not dangerous*) were expected to be read faster after metaphor expressions, while those containing a literal referent (*Lawyers are not sharks because lawyers are not fish*) were expected to be read faster after simile expressions.

Methods

Participants

One hundred and twenty participants, all students from Concordia University, were given course credit or monetary compensation for participating in this study. All participants were native speakers of English and had normal or corrected-to-normal vision. They all provided signed informed consent. The experiment was approved by the Concordia University Human Research Ethics Committee (protocol 10000023).

Materials and design

We used 20 topic-vehicle pairs (e.g., *lawyer-shark*) from a normed set of metaphors and similes (Roncero & de Almeida, 2015) to create 20 negated metaphor and simile sentences (e.g., *Lawyers are not (like) sharks*). Each sentence was also followed by an explanation. For the metaphors and similes, we selected vehicles that could activate a salient figurative attribute and also a strong literal representation. Toward this goal, for the figurative explanations, we used the property that Roncero and de Almeida reported had been written most often for a given topic-vehicle pair. More specifically, the most frequent property written for a given topic-vehicle pair as a metaphor was the property used in the explanations that expressed figurative properties. For the literal sentences, a literal property was selected. This literal property was often the vehicle's literal category (e.g., *plant* for the metaphor *Education is a tree*, and *fish* for the metaphor *Lawyers are sharks*). A list of the negated topic-vehicle pairs and the properties used in the explanations are presented in the Appendix.

The 20 topic-vehicle pairs were presented as metaphors or similes for self-paced reading, segment by segment, as follows (with "+" representing parts of the sentence which were visible individually): Introduction + topic + (*is not*/*is not like*) + vehicle + *because* + explanation + closing statement. Crucially, metaphor and simile sentences differed only at the "*is not*/*is not like*" position. Introductions always consisted of two words, and had the form of attitude reports *Bob says, Mary thinks, Ted believes*, and so on. Closing statements had the form "*It was* _____" with the blank filled by a phrase that provided the statement with a sense of time or place; for example, *It was written on a website; It was uttered to a man*, and so on. These closing statements were used to capture any spill-over effects after

the vehicles and explanations. Since our expressions, until the explanation region, would differ only by the word *like*, we were concerned that presenting participants both our metaphor and simile expressions might lead to some participants ignoring the presence of the word *like* in the sentence. To address this concern, we ran our expression by explanation conditions as a between-group condition. Thus, one group read negative metaphors followed by explanations negating figurative attributes, while the next group read negative similes followed by explanations negating figurative attributes. Two additional groups were run for metaphors and similes followed by explanations negating literal attributes. For each of the four groups, the 20 experimental items were presented with 30 filler items. The filler items were metaphors and similes that contained topic-vehicle pairs not used in the set of experimental items, which were also followed by related explanations. The filler sentences were affirmative rather than negated sentences.

Procedure

Stimuli were presented on a 20" Viewsonic monitor attached to a Macintosh computer running PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993). Participants were asked to read normally for comprehension, using a self-paced reading with moving window paradigm. After the procedure was explained, participants were given 15 practice trials consisting of both metaphors and similes that were not employed in the main experimental set of materials. The sentences were first presented completely as dashes replacing each letter in the sentence. Once the participant pressed a button, the introduction appeared, while the rest of the sentence was still represented as dashes. When the participant pressed the button a second time, the topic appeared, and the introduction was replaced with dashes. Therefore, only one sentence fragment was visible on the screen at a time. To ensure participants also maintained attention, rather than passively pressing buttons, we also asked participants to rate on the computer keyboard using a 1-to-7 scale how apt they found the sentence. *Politics is a jungle* was given as an example of an apt statement, whereas *Politics is a beach* was given as an example of a less apt statement. Responses were collected on a CMU response box which had three buttons; the middle button was used to collect reading times. The experiment lasted approximately 30 minutes.

Results

Outlier removal

For each participant, all vehicle reading times (RTs) shorter than 200 ms and longer than 5000 ms were removed (0.29% of all data points). For the explanation region, RTs shorter than 200 ms and longer than 10,000 ms were removed (0.91% of all data points). For each participant, the mean and standard deviation of the remaining RTs for the vehicle and explanation region were then calculated. A participant's RT was considered an outlier if it was larger than the mean plus 2.391 standard deviations, or smaller than the mean minus 2.391 standard deviations. This standard deviation value is the number recommended by Van Selst and Jolicoeur (1994) for the removal of outliers in a sample size of the present magnitude. These outliers were replaced with the boundaries (i.e., $M + 2.391\ SD$ for RTs greater than this value, and $M - 2.391\ SD$ for RTs smaller than this value). A total of 144 data points were changed (corresponding to 6% of the dataset). Given that we ran independent groups, we also ran outlier removal across participants within a condition to ensure that the distribution of outliers across the different conditions was the same. For the vehicle and explanation conditions, participants whose mean RTs were longer than the group mean plus (or minus) 2.43 standard deviations had their means removed and not replaced. For the vehicle condition, 4 participants were removed (3.34% of all data points), while for the explanation condition, 4 different participants were removed (2.88%). This criterion is also the one recommended by Van Selst and Jolicoeur (1994).

Data analyses

We conducted linear mixed effects (LME) models (Baayen, Davidson, & Bates, 2008) using the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015) for the R statistical programming environment (R Dev. Core Team, 2011). For all analyses, sentence type (metaphor/simile conditions) and literality (figurative/literal) were included as fixed effects. Furthermore, all models included only random intercepts for subjects and items, as justified by the likelihood tests, given that the simple model could not be rejected in favor of a more complex model. The models analyzed the effects of sentence type and literality on participants' RTs to the vehicle region, RTs to the explanation region, and aptness ratings. We derived *p*-values for all main effects and interactions using the Likelihood Ratio Test to compare the full model to a reduced model excluding the relevant term (Winter, 2013, 2019). Planned comparisons were conducted with the *emmeans* package using Tukey's correction (Lenth, Singmann, Love, Buerkner, & Herve, 2018). Inspection of residual plots showed deviations from homoscedasticity and normality for RTs to vehicle and explanation regions. Those analyses relied on log-transformed data.

Vehicle reading times

The full model was compared to a null model consisting of only random predictors and was found to provide a statistically significant better fit to the data, $\chi^2(3) = 18.84$, $p < .001$. There was a significant main effect of sentence type, $\chi^2(1) = 12.54$, $p < .001$, no significant main effect of literality, $\chi^2(1) = 1.51$, $p = .22$, but a significant interaction, $\chi^2(1) = 4.95$, $p = .03$. Planned comparisons between metaphors and similes showed that participants took significantly longer to read the vehicle (e.g., *shark*) when it was embedded in a negated simile (e.g., *Lawyers are not like sharks*) than when it was a constituent of a negated metaphor (e.g., *Lawyers are not sharks*;$t(112) = 3.66$, $p < .001$). That is, sentence type affected RTs in the vehicle region, increasing it by 162 ms, 95% CI [63.66, 260.18] (see Table 1 for all descriptive stastistics, and Table 2 for a summary of all LME analyses). This result suggests that negated similes trigger a more difficult comprehension process than do negated metaphors, which is consistent with the idea that similes are more difficult to comprehend than metaphors (Barnden, 2012; Bowdle & Gentner, 2005; de Almeida et al., 2010; Glucksberg, 2008).

Explanation reading times

The full model was evaluated relative to a null model consisting of only random effects and was found to be a statistically significant better fit to the data, $\chi^2(3) = 8.19$, $p = .04$. There was not a significant main effect of sentence type, $\chi^2(1) = .37$, $p = .54$, nor a significant main effect of literality, $\chi^2(1) = 1.74$, $p = .19$. But there was a significant interaction, $\chi^2(1) = 6.08$, $p = .01$. Literality had an effect on RT to the explanation region, which was modulated by the sentence type, increasing it by 190 ms, CI 95% [−193.22, 573.80]. Planned comparisons between metaphors and similes across the levels of literality revealed no

Table 1. Means for RT to vehicle, RT to explanation, and aptness scores.

	Sentence type	Literality	M	SD
RT to vehicle	Metaphor	Figurative	653.20	97.99
		Literal	692.69	109.31
	Simile	Figurative	932.60	198.96
		Literal	734.80	90.72
RT to explanation	Metaphor	Figurative	1801.33	332.62
		Literal	1995.16	411.83
	Simile	Figurative	2105.05	373.67
		Literal	1695.82	348.27
Aptness ratings	Metaphor	Figurative	3.33	0.79
		Literal	4.23	0.59
	Simile	Figurative	3.35	0.73
		Literal	4.65	0.59

Table 2. Mixed-effects linear model of RT to vehicle, RT to explanation, and aptness ratings.

	Predictors	β	SE β	*t*-value	95% CI of β	*Null Comparison*
RT to vehicle	(constant)	2.75	0.03	101.63	[2.69, 2.80]	
(*log*)	sentence type	0.15	0.04	4.15	[0.08, 0.22]	**$\chi^2(1) = 12.54$, $p < .001$**
	literality	0.02	0.04	0.69	[−0.05, 0.09]	$\chi^2(1) = 1.51$, $p = .22$
	sentence type * literality	−0.11	0.05	−2.21	[−0.21, 0.01]	**$\chi^2(1) = 4.95$, $p = .03$**
RT to explanation	(constant)	3.20	0.03	107.84	[3.10, 3.23]	
(*log*)	sentence type	0.02	0.03	0.60	[0.01, 0.18]	$\chi^2(1) = .37$, $p = .54$
	literality	0.03	0.04	0.79	[−0.05, 0.12]	$\chi^2(1) = 1.74$, $p = .19$
	sentence type * literality	−0.15	0.06	−2.46	[−0.27, −0.03]	**$\chi^2(1) = 6.08$, $p = .01$**
Aptness ratings	(constant)	3.237	0.2168	14.931	[2.80, 3.66]	
	sentence type	0.2167	0.2246	0.965	[−0.22, 0.66]	$\chi^2(1) = 0.91$, $p = .34$
	literality	1.0994	0.2246	4.896	[0.65, 1.54]	**$\chi^2(1) = 21.85$, $p < .001$**
	sentence type * literality	0.39655	0.44759	0.886	[−0.48, 1.28]	$\chi^2(1) = 0.80$, $p = .37$

statistically significant difference for metaphors ($t(112) = 0.62$, $p = .54$). Numerically, however, metaphors that were followed by explanations negating figurative properties ($M = 1801$ ms, $SD = 333$) were read faster than those that were followed by explanations negating a literal property ($M = 1995$ ms, $SD = 411$). In the case of similes, the reverse effect was found significant ($t(112) = 2.69$, $p = .04$), whereby similes that were followed by explanations negating a literal property were read significantly faster ($M = 1695$ ms, $SD = 348$) than similes that were followed by explanations negating a figurative property ($M = 2105$ ms, $SD = 374$). Figure 1 shows the mean RTs for explanations as a function of sentence type and literality type.

Aptness ratings

For aptness rating, the full model was compared to a null model consisting of only random effects and was found to provide a statistically significant better fit to the data, $\chi^2(3) = 23.40$, $p < .001$. There was not a significant main effect of sentence type, $\chi^2(1) = .91$, $p = .34$. There was a significant main effect of literality, $\chi^2(1) = 21.85$, $p < .001$, with aptness scores increasing by 1.09, 95% CI [0.65, 1.54]. There was not a significant interaction, $\chi^2(1) = .80$,$p = .37$. Planned comparisons between sentences with literal and figurative explanations showed that sentences with explanations negating a figurative property yielded significantly lower mean aptness ratings than sentences with explanations negating a literal property ($t(112) = 4.84$, $p < .0001$). That is, regardless of whether the sentence was a metaphor or

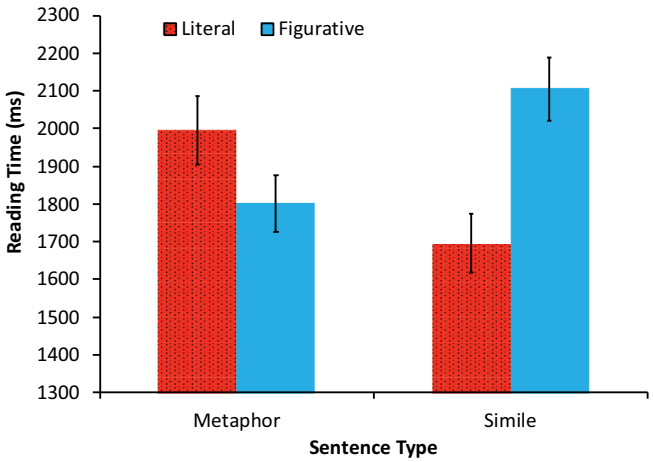

Figure 1. Reading times for the explanation region of the negated metaphor (*Lawyers are not sharks* . . .) and simile (*Lawyers are not like sharks* . . .) sentences when the main property presented in that region is either figurative (. . . *because lawyers are not dangerous*) or literal (. . . *because lawyers are not fish*).

simile, sentences with explanations negating a literal property (metaphor: $M = 4.24$, $SD = 0.60$; simile: $M = 4.66$, $SD = 0.60$) were rated more apt than sentences with an explanation negating a figurative property (metaphor:$M = 3.34$, $SD = 0.79$; simile:$M = 3.36$, $SD = 0.73$). Notice that these results should be seen with caution for we are treating aptness as a continuous variable on the assumption that the categories of our aptness scale have an underlying continuity.

Discussion

Participants read metaphors and similes followed by explanations. Sentences were read using a self-paced moving window, which allowed us to compare reading times for the vehicle region alone. Vehicles had longer reading times when they were read within a simile compared to when the same word was read in a metaphor. Furthermore, this result was found despite the sentences being negated (e.g., *Lawyers are not (like) sharks*). Explanations were also written to refer to (and negate) either a figurative property of the vehicle (e.g., *dangerous* for *shark*), or a more literal property of the vehicle (e.g., *fish* for shark). Consistent with our predictions, explanations that negated a figurative property were read faster when they followed metaphors, whereas the reverse, however, was observed for similes: explanations that negated a literal property of the vehicle were read faster following similes. These results are also consistent with Glucksberg's (Glucksberg, 2008; Glucksberg & Haught, 2006) view that while the vehicle is interpreted figuratively in metaphors, it is interpreted literally within similes. Statements were rated also more apt when the explanation negated a literal property (e.g., *Lawyers are not (like) sharks because lawyers are not fish*) rather than a figurative property (e.g., *Lawyers are not (like) sharks because lawyers are not dangerous*). Thus, participants deemed the statements less acceptable when they negated a figurative property. Indeed, the mean aptness rating for explanations negating a figurative property was below the scale's mid-point of 4 (labeled moderately apt) for both metaphors and similes, whereas the mean aptness rating for explanations negating a literal property was above this mid-point.

These aptness results also provide indirect evidence for Hasson and Glucksberg (2006) claim that negated metaphors first activate affirmative-related properties rather than negative-related properties. Had reading a negated statement such as *Lawyers are not sharks* activated properties associated with *kindness* (a property implied by the negated metaphor), then aptness ratings would have probably shown a relative increase because the written sentence would have supposedly matched the activated mental representation of lawyers being *kind*. Instead, the results suggest that when people read a statement such as *Lawyers are not sharks*, they first entertain the affirmative statement (*Lawyers are sharks*), which in turn might activate a salient affirmative-related property (i.e., *dangerous*). Thus, a statement such as *Lawyers are not sharks* would *first* be interpreted as implying that *Lawyers are not dangerous*, rather than implying that *lawyers are kind* (Giora, Balaban, & Fein, 2005). When participants then read a sentence that contradicts this mental representation (i.e., *Lawyers are not sharks because lawyers are not dangerous*), it is possible that participants rate the statement as less apt because it does not match the salient representation just accessed. Another possibility is that negating metaphors in the form *X is Y* affects comprehension in a different manner than it would the comprehension of literal sentences. Specifically, it has been argued that negation within some such metaphors increases the salience of the metaphorical meaning, which is being rejected, when compared with any potential literal meanings associated with the vehicle (Giora, Fein, Metuki, & Stern, 2010). That is, the negated figurative interpretation of certain metaphors may be more salient than the affirmative figurative meaning. Giora et al. (2013) argue that this effect occurs primarily in the processing of unfamiliar metaphors free of explanatory context, and can cause negated metaphors to be processed faster in their figurative sense than in their literal sense. This could further explain why similes – which invite literal comparisons – were read slower at the vehicle position in their negated form compared to metaphors with the same constituents.

Finally, the finding that metaphors and similes may elicit different vehicle-related representations, and ultimately how the topic-vehicle pair relationship itself might be interpreted differently in the two

expressions, is problematic for theories such as career of metaphor. Recall that this theory predicts that novel metaphor statements can be understood as similes. If vehicles are interpreted literally within similes, and if conventionalization does not change the meaning produced in a simile versus a metaphor, then metaphors should also yield literal representations of the vehicle. Instead, the results found in the present study support the argument that the vehicle is interpreted figuratively in metaphors (or triggers access to a figurative property), but literally in similes. Consequently, the results are more supportive of a theory that argues that metaphors are understood as categorizations, consistent with a metaphor's copular *X is Y* structure (Glucksberg, 2008). The categorization theory, however, also predicts aptness to affect metaphor processing, but we did not find aptness ratings to be related to vehicle reading times.

If we adopt the hypothesis that similes would be understood as comparisons, but metaphors as categorizations, given their respective structures, we might ask, why would understanding similes as comparisons cause longer vehicle reading times? Adopting the working hypothesis that different structures (*X is Y* vs. *X is like Y*) trigger different interpretive mechanisms, metaphors more often generate inferences on what is possibly "sharky" about a lawyer (see de Almeida, 2018), whereas similes generate inferences on how lawyers might be comparable to sharks. The latter processing might take longer, assuming that there are great many possible ways in which *X*'s might be like *Y*'s. Thus, while a metaphor form provides a recipe for making *Y* the qualifier for *X*, the simile form is an invitation for thinking about the comparison between *X* and *Y*, which is boundless. In turn, metaphor processing is predicted to be faster than simile processing because the projection of a certain qualifier is easier than the boundless inferences demanded by similes. An argument along the same lines, though perhaps with a different result, is made by the career of metaphor theory (Gentner & Bowdle, 2008): a *comparison* (i.e., simile) requires an "alignment" process between the topic and vehicle followed by a "projection" of those properties found to be in common between topic and vehicle. In contrast, for *categorical* processing (i.e., metaphor), career of metaphor theory argues that a meaning associated with the vehicle term is simply projected onto the topic – without an alignment stage. Thus, categorical processing is predicted to be faster than comparative processing because fewer processing stages are required. The difference between our proposal and that of career of metaphor is that, while they see the alignment as based on sets of features taken from topic and vehicle, we propose that the processes of attaining a simile is by sets of *inferences* that compare the two terms – thus without committing to lexical meaning as feature-based, which relies on an analytic/synthetic distinction (de Almeida & Antal, 2020). While the present study is unable to identify the specific type of processing involved (inferences vs. projection vs. alignment), we do note that the results found in the present study are consistent with the hypothesis that vehicles require more processing time when read within similes than when read within metaphors.

Conclusion

The results support the hypothesis that metaphors and similes are neither processed similarly, nor yield similar interpretations: we rather propose that they compute different semantic representations in the process of building interpretations in real time. Vehicles produced longer reading times when read in similes, suggesting that processing similes is more difficult than processing comparable metaphors. Furthermore, the vehicle is assigned a more literal or more figurative meaning, depending on the type of structure that it is embedded in (*X is Y* in metaphors, or *X is like Y* in similes). The present study found support for this prediction because, crucially, explanations with figurative properties were read faster following metaphors, while those with literal properties were read faster following similes. Thus, contrary to Aristotle's predictions – and many of his current followers's expectations – metaphors and similes compute different semantic representations.

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Appendix: Experimental sentences employed in the self-paced reading task

Topic (*lawyers*) and vehicle (*sharks*) pairs are embedded in the sentence, in italics. Sentences can be in either metaphor or simile (with *like*) form and followed by a literal or figurative explanation.

Sentence	Literal property	Figurative property
(1) Bob says *music* is not (like) *medicine* because	music is not a drug.	music is not addictive.
(2) Tim thinks *clouds* are not (like) *cotton* because	clouds are not fibers.	clouds are not soft.
(3) Jim thinks *dreams* are not (like) *water* because	dreams are not liquid.	dreams are not clear.
(4) Sam believes *education* is not (like) a *tree* because	education is not a plant.	education does not grow.
(5) Tom feels *memory* is not (like) a *river* because	memory is not a stream of water.	memory does not flow.
(6) Bob says *men* are not (like) *fish* because	men are not aquatic animals.	men are not slippery.
(7) Tim thinks *life* is not (like) a *beach* because	life is not full of sand.	life is not relaxing.
(8) Jim thinks *wisdom* is not (like) an *ocean* because	wisdom is not a body of water.	wisdom is not vast.
(9) Tom feels *anger* is not (like) a *heart* because	anger is not an organ.	anger is not an red.
(10) Bob says the *bible* is not (like) a *sword* because	the bible is not a weapon.	the bible is not sharp.
(11) Tim thinks *typewriters* are not (like) *dinosaurs* because	typewriters are not reptiles.	typewriters are not extinct.
(12) Jim thinks *hair* is not (like) a *rainbow* because	hair is not the sun's reflection.	hair is not the colorful.
(13) Sam believes *heaven* is not (like) a *treasure* because	heaven is not a precious thing.	heaven is not golden.
(14) Jim thinks *love* is not (like) a *child* because	love is not a person.	love is not innocent.
(15) Sam believes *love* is not (like) a *melody* because	love is not a song.	love is not relaxing.
(16) May knows *tongues* are not (like) *fire* because	tongues are not flames.	tongues are not hot.
(17) Tom feels *perjury* is not (like) a *boomerang* because	perjury does not a weapon.	perjury does not return.
(18) Tim feels *television* is not (like) *candy* because	television is not sugar.	television is not sweet.
(19) Bob says *lawyers* are not (like) *sharks* because	lawyers are not.	lawyers are not dangerous.
(20) Tim thinks *women* are not (like) *cats* because	women are not felines.	women are not soft.