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Interpreting Metaphors in Real-time: Cross-modal Evidence for Exhaustive Access

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Abstract

Natural language is replete with figurative expressions like *my lawyer is a shark*, and listeners are expected to intuitively understand the intended, rather than the literal, meaning of such expressions. But what cognitive resources are involved in attaining meaning for such sentences? Most research into metaphor comprehension has employed *offline* reading tasks that provide no insight into the time-course of metaphor processing. In order to investigate the moment-by-moment on-line processes involved in metaphor comprehension, the present study used a naturalistic cross-modal lexical decision paradigm (Swinney, 1979) with novel brief masked target presentations during and after the vehicle word (*shark*). Results obtained from a preliminary sample demonstrated priming of related target words across conditions, but no significant differences between conditions. These results may best be interpreted as supporting an exhaustive-access account of metaphor interpretation, which suggests that literal and metaphorical interpretations are simultaneously accessed during the early stages of metaphor/simile interpretation.

Keywords: metaphors; similes; language comprehension; psycholinguistics; cross-modal lexical decision task; pragmatics

Introduction

How are metaphors interpreted in real time? This question is central to cognitive science because metaphors involve blatantly false statements that are nonetheless easily understood as conveying an ulterior, non-expressed meaning. For instance, upon hearing *my lawyer is a shark,* the listener does not call out the absurdity of the speaker's statement, rather assigning to it an interpretation that supposedly captures the speaker's intended meaning.

Various theories have been proposed to account for how listeners attain meaning for nominal metaphors in the form *X is Y*. Pragmatic theories take metaphors to convey initially a *literal* meaning which works as an invitation for the reader/listener to an interpretation based on the speaker's intended meaning (Davidson, 1978; Grice, 1975; Searle, 1979). While these authors differ in their approach to how metaphor is ultimately understood, they all suggest that the intended meaning can only be understood after an initial rejection of the literal, propositional meaning. In psycholinguistic circles this has been known as the *pragmatic model*, on the assumption that comprehension involves a three-stage process, beginning with the literal interpretation, followed by a rejection of the literal, and a search for the metaphorical meaning.

By contrast, the *direct-access* model suggests that metaphors are immediately comprehensible by the linguistic system and do not involve additional cognitive resources (e.g. Glucksberg & Keysar, 1990; Gibbs, 1994; Wolff & Gentner, 2000). Direct access is obtained either via a mechanism where metaphors are taken as comparisons between categories (e.g. Glucksberg & Keysar, 1990; Glucksberg, 2003), or via mapping of *constituent features* (say, features of *lawyers* and *sharks*), which are stored in the linguistic system as lexical properties of individual words (Wolff & Gentner, 2000). [1]

Although metaphors are pervasive in natural language and cognitive scientists have long debated the nature of their interpretation, to date few empirical studies have investigated the moment-by-moment process of metaphor comprehension using *online* experimental methods such as cross-modal priming with lexical decision (CMLD; e.g., Blasko & Connine, 1993); self-paced reading (e.g., Janus & Bever, 1985); ERP (Pynte, Besson, Robichon & Poli, 1996), and eye-tracking (Ashby, Roncero, de Almeida, & Agauas, 2018). However, support for the *direct-access* view is based primarily on studies involving *offline* tasks, i.e., tasks that require conscious judgment, and are thus not informative regarding what happens as sentences containing metaphors unfold in real time.

For instance, Glucksberg, Gildea, and Bookin (1982) asked participants to read literal and metaphorical sentences and to judge whether they were literally true or literally false. Based on a finding that it took longer for participants to judge statements as false if they had a common metaphorical interpretation (e.g. *jobs are jails*), the authors concluded that a metaphorical meaning is immediately available along with a literal meaning and thus interfered with subjects' classification of metaphorical sentences as

[1] The theories briefly mentioned here certainly do not exhaust the spectrum of metaphor theories. However, we restricted our review to theories concerned with the process of incremental interpretation, while leaving aside theories about the thinking processes that are triggered by or underlie metaphor production and comprehension (e.g., Lakoff & Johnson, 1978).

literally false (Glucksberg et al., 1982). The results obtained by *offline* studies such as Glucksberg and colleagues' (1982) could be equally compatible with the hypothesis that pragmatic processes interfere with literality judgments after the sentence has been fully processed, but before participants register a response.

Studies investigating on-line metaphor processing by measuring event-related potentials (ERP) have demonstrated that figurative targets elicited larger N400 amplitudes than literal targets (e.g. Pynte et al., 1996; Lai, Curran, & Menn, 2009), which suggests that figurative expressions are more difficult to process. This could be due to the detection of an incongruence between literal and intended speaker meaning. Crucially, these studies have not investigated what is accessed at the point at which a figurative expression is first processed.

The purpose of the present study was to investigate the nature of the representations computed during the real-time processing of metaphors and similes containing the same constituents, using an *online* cross-modal priming task. Specifically, we aimed to compare these two types of expressions in real time to elucidate differences in processing that might occur due to their fundamentally metaphorical and literal nature, respectively, and by doing so to shed light on the cognitive mechanisms involved in reaching an understanding of the meaning of such constructions. Our study is unique in that we aimed to study the very earliest moments of metaphor processing—the moment of lexical access—rather than later interpretation processes, and aimed to develop a new, more time-sensitive measure than in previous studies (e.g. Blasko & Connine, 1993).

We sought to compare the moment-by-moment comprehension of nominal metaphors in the form *X is Y* and similes in the form *X is like Y* using a cross-modal lexical decision task (CMLD; Swinney, 1979), and thus limited our study to nominal metaphors which could be compared to similes directly. Though they are traditionally thought to be an alternate form of the simile – a view dating back to Aristotle (trans. 1926) – the key difference between these two forms of expression is the word *like* in a simile, which renders it literally comprehensible. There is evidence that metaphors and similes are produced and understood differently (Ashby et al., 2018; Roncero, de Almeida, Martin, & de Caro, 2016; Roncero, Kennedy & Smyth, 2006) and yield different properties in offline studies (Roncero & de Almeida, 2015). Thus, we chose to use simile sentences as a literal control condition for nominal metaphor sentences due to their nearly identical constituent structure.

In the CMLD task, participants listen to aurally presented sentences for comprehension and are simultaneously presented with a visual target to perform a lexical decision task (i.e., pressing "yes" if the target is a word, "no" otherwise) in which response times (RTs) are collected. The main assumption behind the technique is that RTs to targets reflect the relation between a visual target and a prime word in the sentence (here, the vehicle *Y*). Specifically, recognition of the target word should be facilitated by hearing a related prime word, and thus yield a faster reaction time compared to a target that is semantically unrelated.

This method has two main advantages over other online techniques such as ERPs and offline tasks such as sentence judgments. First, listening to spoken metaphors during an *online* lexical decision task allows for an analysis of metaphor interpretation that is both highly time-sensitive and naturalistic. Using a simple lexical decision task rather than an *offline* judgment task means that participants do not base their responses on a conscious assessment of sentence meaning – indeed, they are not aware that this task is meant to test their comprehension of metaphors at all. Instead, priming for each target should reflect the interpretation of a sentence that is available at the moment visual targets are presented. Second, using similes as literal controls allows for all constituent words besides *like* (including target and vehicle) to remain identical, thus allowing for direct comparisons between literal and figurative interpretations of each topic-vehicle pair.

To our knowledge, the only other metaphor processing study to employ CMLD was that of Blasko and Connine (1993), which employed a substantially different method. In their study participants listened to metaphors and responded to targets presented at the offset of the vehicle. These targets were either (a) metaphor-related, (b) literal-related, or (c) control (unrelated to either the metaphor or the literal interpretation). In the present study, in addition to comparing metaphor to simile, we traced the time-course of interpretation by employing two target presentation points, thus probing for the potential access to literal or metaphorical interpretations over time. In addition, our first probe point was before the offset of the vehicle, during its *recognition point,* to test for the earliest possible position in which a literal or metaphorical interpretation could be obtained. Moreover, unlike Blasko and Connine (1993), our targets were forward- and backward-masked with a series of crosshatches, and presented at a fast rate (80ms) in an attempt to circumvent subjects' potential detection of a relation between prime and target.

Method

Participants

Participants were 37 native English speakers between the ages of 19 and 59 (M = 26.32, SD = 8.07; 26F) with normal or corrected-to-normal vision and hearing who met the following inclusion criteria: (1) They learned English before the age of 5 (M = 1.19, SD = 1.47) and identified it as their native and dominant language; (2) they rated themselves as fluent in speaking, listening, and reading English; (3) they reported no history of hearing or reading disability. Participants who were recruited via Concordia University's online participant pool were compensated with course credit while all other participants were compensated with $10 for one hour of participation. Participants for two pretests are described along with the pretests below.

Materials Experimental materials consisted of 32 sentences containing metaphors/similes in the form *X is (like) Y* and 160 filler sentences. Metaphor/simile sentences were selected from Roncero and de Almeida (2015), which consists of a set of metaphor/simile sentences with accompanying norms. The sentences were chosen on the basis of their high aptness ratings (rated above 6 on a scale of 1 to 10, with 10 being the most apt), but had a broad range of familiarity ratings. The Roncero and de Almeida (2015) norming study asked participants to generate associates/explanatory words for both the simile and metaphor versions of each sentence and for the topic and vehicle words in isolation. For use as our figuratively related targets, we selected explanatory words generated for each metaphor by the highest possible number of participants, which did not appear as associates for the vehicle word in isolation. For our literally related targets, we selected words which were generated as associates of the vehicle word by the highest possible number of participants and which did not appear as explanatory words for the metaphor on the whole.

Exclusion of Automatic Associates To ensure that any potential priming effects were not derived from an 'automatic' association between the vehicle and target words (i.e., due to being frequently paired in speech, like *salt* and *pepper*), we conducted a norming experiment where each vehicle word was read aloud to 12 native speakers of English, who were asked to say out loud the first word that came to mind. Their responses were collected and any word which was named more than twice was excluded from selection as a target for that vehicle word.

The unrelated control words selected to calculate priming effects were chosen according to the following criteria: For each related target word, written frequency was calculated from the Corpus of Contemporary American English (COCA; Davies, 2008), a database of American English texts collected from 1990-2017 including fiction, non-fiction and academic texts. Matched (unrelated) control words were selected to have the same number of letters, same number of syllables, same morphological structure and similar frequency in the COCA database.

Sentence Recording and Target Selection Metaphors/similes were embedded in longer sentences with explanatory contexts which we generated, with the word *because* following each vehicle word to control for interference from explanatory contexts; these sentences also began with generic *proposition-attitude* statements (e.g., *It is hardly a secret that lawyers are sharks, because with few exceptions, lawyers are bloodthirsty and ruthless*). Filler sentences did not repeat the topic or vehicle words of any experimental sentences. Of these, 32 followed a similar sentence structure as experimental sentences, while 128 filler sentences did not syntactically resemble experimental sentences. Visual targets for filler sentences were 64 real English words and 96 'nonsense' strings of letters that did not resemble English words, of varied lengths to reflect the varied lengths of experimental targets. All sentences were read by a female native English speaker and recorded for aural presentation, with natural prosody and reading speed. Special attention was given to matching the prosody and timing of metaphor and simile pairs, to make them nearly identical except for the word *like*.

Recognition Times We employed a gating paradigm to determine the recognition point of each vehicle word, following the procedure developed by Zwitserlood (1989). Recordings of each vehicle word were cut into slices increasing by 50ms each. These were played consecutively to 10 native speakers of English over noise cancelling headphones. Participants were asked to write down what word they thought they were hearing after each slice was presented. Their responses were collected and recognition times for each word were defined as the moment when 80 percent of participants correctly identified the word (with or without pluralization). During the lexical decision task, the early time point was defined as 40ms prior to recognition time, to account for screen refresh rate and the fact that the word could have become recognizable anytime within the 50ms slice participants heard during the gating task. Late time points were defined as 500ms following recognition time to avoid interference from words later in the sentence.

Experimental Design

A total of 16 counterbalanced lists were created following a 2 x 2 x 2 x 2 design. Each topic/vehicle pair was presented in either a metaphor- or simile-containing sentence, along with a figuratively related target, literal target or matched control target, at an early (*recognition*) or late time point. Each block contained two experimental sentences in each condition along with all 160 filler sentences, 20 of which were followed by comprehension questions to ensure participants were attending to aural stimuli. Each participant completed two blocks containing one list each – i.e., each participant heard both the simile and metaphor version of each sentence once in total. The sentences were randomized in order within each block of trials and participants were randomly assigned to each set of lists.

Procedure

Participants were tested on an iMac computer using Psyscope X B57 (Cohen, MacWhinney, Flatt, & Provost, 1993) using a button box. After voluntary consent was obtained, each participant was seated in front of the screen in a dark room, equipped with noise-cancelling headphones, and instructed to attend to both the aurally presented sentences and visual stimuli on the screen. Participants were instructed that their primary task was to identify whether the letters they saw on the screen constituted an English word and to press a button to indicate YES or NO as quickly and accurately as possible, while their secondary task was to answer comprehension questions about the sentences they heard over the headphones.

Each trial consisted of a prompt asking participants to press a button when they were ready for the next trial, followed by an aural presentation of each sentence. Target words appeared in white 20-point Arial font text in capital letters on a black screen for 80ms each, preceded and followed by masks which appeared for 100ms. This brief masked priming procedure was meant to reflect faster and more automatic processes of recognition rather than slower processes of judgment. Masked priming (see Forster, 1999) reflects early processes of lexical recognition which should be uncontaminated by other semantic factors. Each participant was given five randomized practice trials, during which the experimenter answered questions and corrected mistakes.

Data Analysis

Analysis of reaction times (RTs) was restricted to correct trials (i.e., those where participants correctly identified the target as an English word) while incorrect trials were omitted (13% of all data points). As is standard in lexical decision paradigms (Friedmann, Taranto, Shapiro & Swinney, 2008), all reaction times above 2 seconds were discarded prior to data analysis (2% of all data points). Based on a priori decisions, we discarded blocks of trials where participants answered fewer than 70% of comprehension questions correctly.

Results

We performed a linear mixed-effects model regression analysis with subjects and items (vehicles) entered as random effects with random intercepts. Raw RTs were regressed on priming (control/experimental targets), sentence literality (metaphor/simile conditions), target type (figurative/literal) and time-point (early/late), as well as all first order interaction terms. For ease of interpretation, priming effects (RT to control – RT to target) are presented in Figure 1. The full RT model was compared to a null model including only random effects (subject and item), using the Likelihood Ratio Test to determine significance. Our model provided a better fit to the data than the null model ($\chi^2(10) = 25.70$, $p = 0.004$). We derived *p*-values for all main effects and interactions using the Likelihood Ratio Test to compare the full model to a model excluding the relevant term (see Table 1) and found only one significant main effect of priming.

As predicted, participants took significantly longer to respond to unrelated targets than to related targets ($\chi^2(4) = 22.38$, $p < 0.001$) – overall, RTs to related targets were 40ms faster (*SEM*=23.88). While no other main terms or interaction terms reached significance, the respective means of each condition seemed to show trends which may be worth investigating with a larger sample. Specifically, in the metaphor condition, early priming values were lower for the figurative condition than for the literal condition, but priming for the figurative condition was higher at the later time point. In the simile condition, the reverse was true, with higher priming for literal targets at the late time point. Unexpectedly, the largest priming effect was observed for figuratively related targets at the early time point of the simile condition.

Table 1: Mixed-effects linear model of response times.

Predictor	Estimate	SE	t	95% CI	Null Comparison
Constant	718.19	23.88	30.08	[671.39, 765.00]	
Priming	-39.51	16.10	-2.45	[-71.06, -7.95]	$\chi^2(4)$=22.38, *p*<.001
Time-point	-1.84	16.05	-0.11	[-33.29, 29.61]	$\chi^2(4)$=1.67, *p*=.80
Target type	-16.44	16.15	-1.02	[-48.10, 15.22]	$\chi^2(4)$=1.27, *p*=.87
Sentence literality	-18.04	16.02	-1.13	[-49.44, 13.37]	$\chi^2(4)$=2.31, *p*=.68
Priming x Time-point	1.43	15.81	0.09	[-29.55, 32.40]	$\chi^2(1)$=0.0083, *p*=.93
Priming x Target type	8.09	15.87	0.51	[-23.02, 39.19]	$\chi^2(1)$=0.26, *p*=.61
Priming x Sentence literality	-4.50	15.83	-0.28	[-35.52, 26.52]	$\chi^2(1)$=0.08, *p*=.78
Time-point x Target type	2.01	15.78	0.13	[-28.93, 32.94]	$\chi^2(1)$=0.02, *p*=.90
Time-point x Sentence literality	14.28	15.77	0.91	[-16.64, 45.19]	$\chi^2(1)$=0.82, *p*=.36
Target type x Sentence literality	10.39	15.88	0.65	[-20.74, 41.52]	$\chi^2(1)$=0.43, *p*=.51

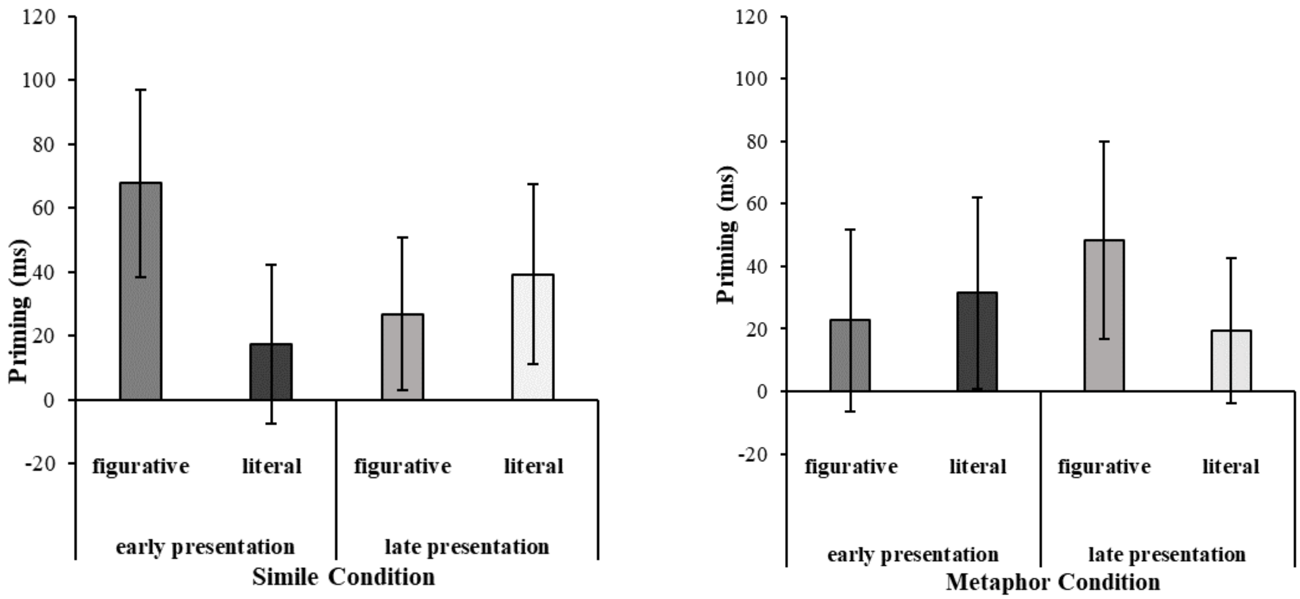

Figure 1: Mean priming effects between unmatched control words and related target words in Metaphor and Simile conditions as a function of time point and literality. Error bars represent SEM

Discussion

We used a novel, masked rapid-presentation CMLD task to gain insight into the moment-by-moment processing of metaphors and similes of the form *X is/is like Y.* The results obtained showed significant priming in all conditions and at all time points; and, contrary to our predictions (and those of the *pragmatic* model) no statistically significant differences in priming between conditions were obtained.

These results can be partially accounted for by different models of metaphor interpretation, in particular models that assume some form of exhaustive access. This is so because, contrary to what both *pragmatic* and direct-access models would predict, literally related target words were still primed as much at the later time point (b) as at point (a), suggesting that even after a sentence has been fully processed (and, presumably, understood to have a non-literal intended meaning), literal representations of the vehicle word linger.

We take these results to suggest that metaphor/simile interpretation trigger an *exhaustive* access, an effect also found in some lexical ambiguity resolution studies (e.g., Swinney, 1979). Exhaustive access, in the context of metaphor processing, entails the access to both the literal meaning and a meaning commonly associated to the metaphorical use of the same word. According to Carston (2010), two simultaneous processes contribute to the understanding of metaphorical language—a fast, *online* formation of *ad hoc* concepts linked to the metaphorical vehicle (for example, while the lexical item *shark* may conceptually represent the large predatory fish, it may also represent a concept like *aggressive* or *mean*, especially for highly apt/conventional metaphors such as many of those used in our experiment), and a more nuanced, *offline* process of interpreting the meaning of a metaphorical passage that relies on its literal meaning and the "images" the literal meaning evokes. Thus, according to Carston's (2010) model, the early priming of figuratively related targets presented at recognition point (a) could be a result of *ad hoc* concept formation relating the vehicle word to figurative concepts, while the persistence of priming for literally related targets at point (b) could be explained by the persistent, simultaneous activation of literal (or imagistic) representations. However, it is not clear whether these *ad hoc* concepts—which are obtained from contextually-driven *inferences*—are in fact accessed within the 80 ms window of target processing. In Carston's relevance-theoretical approach, these *ad hoc* concepts would have to be constrained by context. But this would imply a sentence type x target type interaction, which we did not obtain. Alternatively, these *ad hoc* concepts are already associated with the vehicles, such that a rapid *shark*→*MEAN* access could be obtained similarly to the literally related *shark*→*BLOOD*.

Our results are also partially compatible with Giora's (2003) graded salience hypothesis and in particular its ancillary hypothesis, *retention*. These hypotheses can be summarized as follows. Effects such as frequency or familiarity lead to a graded representation for meanings or senses of a word. These factors determine a form of exhaustive, but ordered access to meanings in the course of interpretation. For metaphors, this means that the most salient meaning—metaphorical or not—will always be accessed first, or activated more strongly. This theory is, in large part, context-insensitive; that is, it takes the order of access to be determined by lexical-semantic encoding factors, not determined by context. We only say that our results are partially compatible with this theory because we have not tested specifically for the salience of particular senses.

A third compatible view takes relations between lexical concepts to be established in terms of meaning postulates (see, e.g., de Almeida, 1999; Partee, 1995; and Fodor, 1998). An application of this view to the interpretation of the present results would take vehicle meanings to quickly trigger their related postulates, whether they are related to literal or to figurative meanings. Thus, for example, a meaning postulate would constitute a relation between the meaning of the prime (*shark*) and the meanings of the targets, via postulates with the form such as $(\forall x[P(x)] \rightarrow [Q(x)])_n$. This view requires both $\forall x[SHARK(x)] \rightarrow [MEAN(x)]$ and $\forall x[SHARK(x)] \rightarrow [BLOOD(x)]$ to be postulates related to the meaning of *shark*, with both being equally primed, independent of context, and as a function of lexical-conceptual relations established not *by necessity* (i.e., *analytic*) but as a function of use (i.e., *synthetic*).[2]

Our results cannot currently set these theories apart, nor was this experiment conceived to contrast them directly. Moreover, despite our exhaustive-access effects, tendencies observed in the group means for each condition suggest that there may be differences in priming between conditions. In the metaphor condition, mean priming for figurative targets was higher at time point (b) than at time point (a), and priming for literal targets was higher at time point (a) than (b), although none of these differences reached a threshold of significance, which may suggest that figurative associations of the vehicle word are accessed more easily after *pragmatic* processes have been implemented. Additionally, priming for figurative targets at time point (b) was higher than for literal targets, which may suggest that literal associations with the target word are inhibited once the metaphor has been fully processed and understood.

Conversely, in the simile condition, group means indicated that priming was higher for literal targets at time point (b) than at time point (a); priming for literal targets at time point (b) was also higher than for figurative targets at the same point (b). These results suggest that similes are interpreted as literally true sentences and tend to activate literal meanings once fully processed, as the *pragmatic* model suggests. One unexpected tendency observed in the group means was that figurative targets were primed more at recognition point (a) than literal targets, and primed more at point (a) in the simile condition than the metaphor condition. A possible explanation for this result is that the word *like* in similes could lead participants to anticipate an upcoming vehicle word that is not typically literally related to the topic of the sentence.

[2] For ease of exposition, we are simplifying the presentation of these meanings postulates, which might involve other predicate-argument relations.

The gating paradigm used to determine recognition points tested the moment at which each word is recognized in isolation, but context could bias listeners to correctly identify the word earlier when presented within a sentence. In the context of highly familiar similes such as *time is like money*, the word *like* could in fact trigger an assumption in the listener that the word *money* will follow, due to the frequency with which the simile is used in common language use—and cause the recognition point of the vehicle word to occur earlier than anticipated. In order to test this possibility, additional experiments are being conducted relating the strength of the early figurative priming effect to the familiarity rating of each simile.

A major methodological difference between our study and other psycholinguistic experiments employing cross-modal lexical priming (e.g., Swinney, 1979; Friedmann et al., 2008) was our use of briefly presented masked visual targets. Typically, cross-modal lexical decision tasks employ an unmasked visual target presentation lasting at least 500ms (e.g. Friedmann et al., 2008), which allows for much higher response accuracy. Forster (1999) explained that the use of very rapid masked primes should circumvent conscious thought processes about prime and target words and, instead, reflect unconscious processes of word association. Our use of masked visual targets presented for 80ms combined with presentation times at the recognition point of aurally presented vehicle words followed the rationale that in order to observe unconscious *on-line* access to semantically related concepts during metaphor processing, participants should not be allowed time to consciously consider either visual target or aurally presented vehicle. This created a speed-accuracy trade-off that resulted in a loss of data; however, the data obtained should be reflective of unconscious (*online*) facilitation processes. Experiments with greater statistical power might resolve whether tendencies observed in support of the *pragmatic* model reflect real differences in priming between conditions. Alternatively, we have also considered three views that seem compatible with an exhaustive access of both metaphorical and literal representations. What our present results seem to indicate is that there is no direct access to the contextually-determined, conventional metaphorical interpretation (e.g., Gibbs, 1994) without access to the literal meaning.

In conclusion, we found priming to targets related to both figurative and literal interpretations of metaphor and simile vehicles. The effect was found at both the recognition point (i.e., before the offset of the *vehicle*), and 500ms later. What is surprising is that we obtained priming effects at a fast target presentation time (80ms) under masking conditions, suggesting exhaustive access to literal and nonliteral-related targets before conscious judgments of metaphoricity could be made.

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