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Does understanding negation entail affirmation? An examination of negated metaphors☆

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Abstract

How do people understand negated assertions? Negation may function like affirmation if it focuses on the counterfactual situation, i.e., the situation ruled out by the statement. Alternatively, negation could shift focus from the counterfactual to the factual situation referred to in the statement. We tested these hypotheses in a study employing a lexical decision task. Participants read affirmative and negated assertions such as *this lawyer is/is not a shark* and then made lexical decisions to terms related either to the affirmative or negative meaning (e.g., *vicious*; *gentle*). In early stages of comprehension, both the negated and affirmative assertions facilitated the accessibility of affirmative-related terms. After 1000 ms, the affirmative assertions continued to facilitate affirmative-related terms, but the negated assertions no longer did so. These results suggest that negations are initially represented as affirmation. We discuss implications for current theories of negation.

Keywords: Negation; Metaphor; Lexical-decision; Counterfactual; Mental-models

1. Introduction

According to mental models (or situation models) theories, understanding text involves constructing models of those situations that are communicated by the text (Garnham and Oakhill, 1992; Glenberg and Mathew, 1992; Glenberg et al., 1987; Zwaan and Radvansky, 1998; Zwaan et al., 2002). Because negation partitions between two types of situations, both those that are true

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and those that are not true, comprehending negation may involve the construction of multiple mental models that correspond to those alternative situations. While previous studies have demonstrated that negation is more difficult in a variety of tasks such as statement verification (Wason, 1961) or picture verification (e.g., Gough, 1965; Slobin, 1966), the online processes involved in its comprehension are not well understood.

Negation is an important topic of study because, among other things, it is perhaps one of the simplest of a class of common linguistic devices whose comprehension involves the consideration of alternative possibilities. Other such devices include counterfactuals (*I wish we had won the game*), counterfactual conditionals (*If we had won, we would be satisfied*), and statements that communicate a contrast with an alternative possibility (*We played hard, but we lost* versus *We played badly and we lost*). Understanding negation can thus contribute towards a more general understanding of how people construct and evaluate alternatives.

One possibility is that negation leads to the construction of two mental representations—one that corresponds to the counterfactual situation, which is said not to occur, and another that corresponds to the factual situation. This notion has been captured by Russell (1948), ''When I say truly 'this is not blue', there is, on the subjective side, consideration of 'this is blue', followed by a rejection''. Analogous arguments appear in both the psychological and linguistic literatures (see, e.g., Gilbert, 1991; Horn, 1989). For example, Langacker (1987) argues that representing negation involves a composite configuration that consists of the representation of the counterfactual possibility as well as the representation of the factual possibility. On this account the focus of attention is shifted from the counterfactual situation (what is said to not occur) to the factual situation (what is actually the case). Such a shift, from counterfactual to factual, may result from an inference prompted by the negation (Manktelow and Over, 1990).

Alternatively, negation could be represented as that which does not occur, perhaps accompanied by a ''mental tag''. According to Fauconnier's (1994) construct of mental spaces, ''negatives set up corresponding counterfactual spaces in which the positive version of the sentence is satisfied'' (p. 96). Thus, one can easily understand statements such as ''I didn't buy a car. There was no room for it in the garage'', where *it* refers to the car that has not been bought. A similar proposal has been made by Clark and Chase (1972), who suggested that when a negation appears in a proposition, it is represented via a marker of falsity. For example, a statement such as *A is not above B* would be represented as *False (A above B)*.

In sum, to the extent that people construct models of situations, it is unclear how many or which models are constructed when understanding negations. One possibility is that only the counterfactual model is constructed (representing the affirmative), but it is tagged as false. Alternatively, two models could be constructed, one corresponding to the factual situation, and the other to the counterfactual situation. These two models might be constructed in parallel, or in temporal succession.

The data on this issue is sparse and inconsistent. Some argue that negations are represented in terms of their affirmations, echoing Russell's contention that to understand a negation, one imagines the affirmative (e.g., Giora et al., 2005a). Giora et al. presented participants with affirmative or negative statements (e.g., *The instrument is/is not sharp*), and 100 ms after reading the statement, participants made a lexical decision to a target word that was related to the affirmative meaning (e.g., *piercing*). Response times to the target words were comparable after reading affirmative or negative primes, suggesting that the mental representation of negation is similar to that of affirmation. However, the probe words used in that study were lexically related to the preceding primes (e.g., *sharp-piercing*) and so the results are also consistent with the

possibility that lexical priming between the sentence-terminal adjective and the target word produced their results, showing no difference between affirmative and negative primes.

MacDonald and Just (1989), in contrast, argued that there is a difference between the representation of negations and their corresponding affirmatives. Participants read statements that referred to two entities, one of which was negated (e.g., *Almost every weekend, Elizabeth baked some bread, but no cookies*). They read such statements at their own pace, and after each statement they were presented with a word on the screen. Their task was to verify whether the presented word had appeared in the preceding statement (exp. 1). These words corresponded either to the negated term (e.g., *cookies*) or to the non-negated term (e.g., *bread*). Verification latencies were used to assess the accessibility of the terms. Verification times were slower for negated terms than for non-negated terms suggesting that, ''negation decreases accessibility of a negated noun'' (p. 641).

Comparable findings were reported by Kaup (2001), who presented participants with statements such as *Almost every weekend, Mary bakes some bread but no cookies for the children* and *Elizabeth tidied up her drawers. She burned the old letters but not the photographs.* Presentation was self-paced, and target words were presented for verification 2.5 s after the end of each statement. As in MacDonald and Just (1989), negations reliably increased verification times. However, the effect of negation interacted with whether or not an entity was implied to be present or absent in the situation model. The difference between response latencies for negated and non-negated nouns was largest when the negated term was absent from the scene and the non-negated term was present at the scene (*Mary* example). However, when the negated term was present at the scene and the non-negated noun was absent (*Elizabeth* example), then the difference between the affirmative and negated terms was smaller.

Previous studies have thus shown that negation may differ from affirmation. In the current study we wanted to examine in detail the way negation differs from affirmation, and whether the divergence between negation and affirmation takes time to develop. People clearly differentiate between affirmative and negative assertions, the issue is when does this difference emerge: immediately, or only with time. We expected that negation would facilitate the accessibility of terms related to the affirmative meaning in the early stages of processing, but not in later stages. Such a pattern of findings would reconcile the seemingly divergent results of earlier studies. Giora et al. (2005a) found no difference between affirmation and negation, but in that study the target word was presented very shortly after participants had read the affirmative and negated sentences. In contrast, in Kaup (2001), the target words were presented only after 2500 ms.[2]

In addition to studying the time course for representing negation, we examined whether negation produces representations that are different from those of affirmation. People may well understand negation by constructing *just* the counterfactual, affirmative meaning (which might

[2] The exact interval is not reported in MacDonald and Just (1989). In addition, the studies by MacDonald and Just (1989) and Kaup (2001) have two design characteristics that make it difficult to directly isolate the effect of negation. First, in these studies negated terms were always contrasted with affirmative terms (e.g., 'no cookies' with bread). Contrasting an affirmative and negative term could imply that the affirmative element is the focus of the statement and therefore the difference in accessibility could be a result of the contrast between a negated and non-negated term, rather than a result of negation per se. Furthermore, the negated terms appeared in the scope of the copula *but*, which is a copula that in itself indicates a deviation from an expectation (Yoshimura, 1997; Blakemore, 1987). The use of *but* could therefore bring to mind a counterfactual situation, and the contrast between this counterfactual possibility and the factual one could lead to increased response times for terms in its scope. It is unknown whether similar results would have been found in these studies if negated terms were not in the scope of *but*; e.g., *He baked a cake with sugar and no eggs*. In such cases the effect of negation could be weaker.

be later suppressed or discarded). However, negation could also prompt further elaboration (Manktelow and Over, 1990), which could lead people to represent the factual states of affairs implied by negated statements.

To examine the representations constructed by negation and affirmation, we used a lexical decision task. We expected that this method would allow us to examine whether negation prompts the construction of both counterfactual and factual representations. Previous studies have used a method based on verification of a single term (e.g., MacDonald and Just, 1989; Kaup, 2001). Such an item-verification method proved adequate for showing that there is a difference between affirmation and negation. However, it does not permit one to infer what sorts of representations are constructed. For example, finding that verification judgments for an item are slower when that item is negated would be consistent with the claim that negation reduces the accessibility of the affirmative representation. However, this finding is also consistent with the possibility that negation prompts the construction of an additional representation, which leads to greater cognitive load and consequently, to slower verification latencies. A lexical decision task, in contrast, allows us to independently examine the relative accessibility of terms related to the counterfactual as well as to the factual meanings.

Our goal in using a lexical decision task was to compare the sorts of representations constructed by affirmation and negation. As mentioned above, when using this paradigm it is important to rule out interpretations based on lexical priming. For example, if one were to find that the target ''happy'' is equally accessible after the statements, *The man was/wasn't laughing*, it would be difficult to say whether this is a result of lexical-level priming between *laughing* and *happy* or an indication of the construction of comparable mental models. To circumvent this interpretive problem, we used metaphorical statements as primes. As we discuss below, metaphors are particularly suitable for this purpose because their meanings (the *ground* of the metaphor) are captured by terms that are not lexically related to the lexical items in the metaphors.

Our purpose in this experiment was to map the timecourse of understanding negation and to examine the representations that result. We therefore manipulated the delay between the offset of a statement and presentation of a target word. We presented negations and their corresponding affirmatives (e.g., *This kindergarten is/isn't a zoo*) and used lexical decisions to target words to assess how each type of statement was mentally represented. Faster decision latencies to negative-related target words (e.g., *calm*) relative to their baseline level (as determined by a control condition) would indicate representation of the factual state of affairs. Faster decision latencies to affirmative-related target words (e.g., *noisy*) relative to their baseline level would indicate representation of the counterfactual state of affairs.

We expected that immediately after reading a negated metaphor, the counterfactual state of affairs would be represented and therefore lexical decisions to affirmative-related targets would be facilitated. To the extent that the factual state of affairs is also represented, then decisions to negative-related targets should also be facilitated. However, given that Giora et al. (2005a) found no difference between affirmation and negation 100 ms after the presentation of a statement, we expected that the representation of the factual state of affairs would only occur in later stages of processing.

We used metaphors for several reasons. First, by using metaphors we could avoid the problem of lexical priming between the prime sentences and the target words. The reason is that terms that are related to the meaning of the metaphor are usually unrelated to the lexical items that constitute the metaphor. Consequently, once lexical priming is ruled out, we could attribute facilitation of lexical decisions to the comprehension of the affirmative or negative metaphors rather than to the presence of a specific word in the metaphor. For example, the statement *This*

lawyer is a shark primes the term *vicious*, but *vicious* is not primed when preceded by the vehicle term *shark* alone (Blasko and Connine, 1993, exp. 5; Glucksberg et al., 2001). In fact, metaphorical interpretations often include emergent features that are not shared by either the metaphor topic or vehicle (e.g., *sneakily illicit* for the lawyer-shark metaphor; cf. Bekker, 1997; Gineste et al., 2000; Tourengeau and Rips, 1991). Second, metaphorical statements offer a unique advantage in studying negation because the negation cannot be transposed, or paraphrased, into affirmative form using lexical knowledge alone. Consider the statement, *This number is not even*. Because the predicate *even* has a contrary antonym, *odd*, the negated predication *not even* may be transposed into the affirmative form, *odd*, on the basis of lexical inference alone. In such case, negation might be interpreted without construction of a situation model that corresponds to the negated proposition. Because negated metaphors cannot be immediately transposed into an affirmative form we expected that the negated proposition – that is, the affirmative – would be accessible after reading a negated metaphor.[3] Finally, we used metaphorical statements that are apt and familiar. Such statements have been shown to be understood immediately (e.g., Blasko and Connine, 1993; McElree and Nordlie, 1999), indicating that their comprehension does not involve an attempt to first understand them literally.

2. Method

2.1. Participants

Eighty Princeton Undergraduate students participated to fulfill a psychology course requirement or for payment.

2.2. Materials

We constructed 32 pairs of affirmative and negative metaphors (e.g., this kindergarten is/isn't a zoo), resulting in 64 experimental items. The initial constraint in constructing the materials was that the metaphors would be sensible and familiar in both affirmative and negative forms. Metaphors have two content words: a topic (e.g., kindergarten) and a vehicle (e.g., zoo). The items were constructed so that topics and vehicles were unique among the metaphors.[4]

Sixty-four words were chosen as lexical decision targets. Thirty-two target words were related to the meaning of the affirmative metaphors, and 32 were related to the meaning of the negated metaphors. Because word length and frequency affect lexical decision latencies, affirmative- and negative-related targets were matched for length and frequency. Affirmative-related targets did not differ from negative-related target words in length (6.03; 6.09), number of syllables (1.96; 2), or frequency (122; 101, Carroll et al., 1971). Given the potential effect of a word's emotional connotation on lexical decision latencies (Vakoch and Wurm, 1997), we note that there was no

[3] The degree to which negation affords an unambiguous implication or inference is likely to affect how quickly the affirmative meaning is discarded. Hasson et al. (2005) found that people are less likely to mis-recall negation for affirmation when the negation offered an inference (e.g., *it is false that this person is a liberal*) than when the negation did not offer an inference (e.g., *it is false that this person is left handed*). This mediating variable was not examined in this paper.

[4] A few items in the experiment were qualified by a quantifier, e.g., "Some workers are not robots". For such items, the construction of the affirmative representation might have been due to the presence of the quantifier, *some*. The pattern and significance levels of the results were not changed when these items were removed from the analysis. We thank Barbara Kaup for bringing this point to our attention.

systematic relation between affirmative-related or negative-related lexical decision target words and affective valence.

We also selected 16 metaphors to be used as unrelated contexts, to provide a baseline control condition. Half were affirmative and half were negative. The affirmative metaphors served as unrelated control contexts for affirmative-related targets and the negative metaphors served as unrelated control contexts for negative-related targets.

We first conducted a norming study to ensure that the candidate target words were related to the meanings of the metaphors, and that the metaphors were sensible and familiar. Forty students who did not participate in the experiment proper participated in this norming study. We were interested in those 64 combinations in which targets matched the meaning of the metaphors (i.e., 32 affirmative and 32 negative sentences followed by their matching target words). Two lists were constructed, each consisting of 16 negative and 16 affirmative metaphors followed by their matching target words. Each participant was given only one list. Participants were instructed to rate the relatedness of each target word to the meaning of the metaphor on a scale of 1 (*completely unrelated*) to 7 (*extremely related*). The relatedness rating was 5.5 for affirmative-related and 5.0 for negative-related targets. Both were reliably greater than the midpoint of the scale ($p < .001$ in each case). The relatedness of affirmative-related words to affirmative metaphors was higher than the relatedness of negative-related targets to negated metaphors, $t(31) = 3.38$, $p < .001$. Although this difference might affect lexical decision latencies in the experiment proper, it poses no interpretive problems because we are interested in the relative accessibility of these terms following affirmative and negative metaphors rather than in a direct comparison between affirmative-related and negative-related targets. These participants were also asked to rate the metaphors for sensibility and familiarity on a scale of 1–7. Affirmative metaphors were rated as more familiar than negative metaphors ($M = 5.3$; 5.0) and were rated as more sensible ($M = 5.9$; 5.5).

We also wanted to make certain that the target words were not highly associated with either the topic or the vehicle of their related metaphors. For this purpose we first used a word-association database (Nelson et al., 1998) to assess the relevant association strengths between metaphor topic and vehicle words and their affirmative- and negative-related lexical decision targets. The measure of association strength was the percent of people who responded to a prime word (metaphor topic or vehicle) with the relevant lexical decision target word. For example, the target words related to the metaphors *some surgeons are (aren't) butchers* were *clumsy* (affirmative-related) and *precise* (negative-related). These words should not be, and indeed were not, highly associated with either *surgeon* or *butcher*. The average association strength measure was below 0.001.[5] Finally, we conducted a lexical decision task to verify that the vehicles of the metaphors did not prime the affirmative-related or negative-related targets. We found no hint of lexical priming between the vehicles of the metaphors and the target words, thus replicating previous studies (Blasko and Connine, 1993, exp. 5; Glucksberg et al., 2001). The details of this norming study are presented in Appendix A.

2.3. Design

The within-subject variables were Prime-type (affirmative, negative or control) and Target-type (affirmative-related or negative-related). The delay between the endpoint of the presented

[5] For instance, the words most frequently associated with *butcher* are animal, baker, block, chef, cleaver, cook, cow, cut, knife, meat, slaughter and wife.

metaphor and presentation of the target word was 150, 500 or 1000 ms, manipulated between-subjects. Twenty participants were assigned to the 150 ms condition, 32 to the 500 ms condition, and 28 to the 1000 ms condition. In sum, the design was 3 (Delay interval) × 3 (Prime) × 2 (Target) with delay manipulated between Ss, and prime and target types within Ss.

The 32 pairs of affirmative and negative metaphors and their corresponding 64 target words are shown in Appendix B. To avoid repetition of materials within participants, four lists were constructed. The 32 metaphors were rotated across the four lists in a Latin-square design so that a metaphor appeared in any given list in either affirmative or negative form, and followed by either an affirmative related or a negative-related target. In addition, each list contained 16 metaphors that were followed by 16 unrelated target-words that did not appear elsewhere in the list—these comprised the control conditions. Each list also contained 48 filler items – half affirmative, half negative – that were metaphors followed by legal non-words (pseudowords). The mean length of the filler metaphors and their non-word targets was comparable to that of the experimental materials.

The proportion of trials on which metaphors were followed by affirmative-related targets was only 17%. That is, only 16 of the 96 trials that participants saw were ones where metaphors were followed by terms related to the affirmative meaning of the metaphor, and half of those trials (8.5% of the total trials) were ones in which affirmative metaphors were followed by targets related to the metaphor's meaning. This low proportion should minimize strategic priming effects, because an expectancy strategy would be sub-optimal (Neely, 1991).

To ensure that participants read the sentences for comprehension, six additional filler metaphors in each list were followed by comprehension questions. Three comprehension questions followed affirmative statements, and three followed negative ones. For example, after the sentence *John's hat was an umbrella over his head*, the comprehension question was, *John owns a hat*?

2.4. Procedure

Participants were told that all the sentences presented would be metaphors and should be understood as such. They were to read the sentence that appeared on the screen, and to press the spacebar after reading it. They were told that following each sentence a string of letters would appear on the screen, and that their task was to indicate whether it formed an English word by pressing one of two keys identified as ''yes'' and ''no''. Participants were asked to read the sentences for comprehension, because some sentences would be followed by yes/no comprehension questions, to be answered by pressing the appropriate yes/no keys. After the instructions, participants performed six practice trials that included one question. A signal appeared at the end of practice to press the spacebar to initiate the experiment proper. The next 12 trials served as practice to stabilize response latencies, followed by the experimental items.

We used three delay intervals: 150, 500 and 1000 ms. In each condition, an orienting asterisk appeared in the center of the screen for 200 ms. The asterisk was then replaced by a priming sentence. After participants pressed the spacebar, the sentence was replaced by an asterisk in the center of the screen for the duration of the delay interval. The asterisk was then replaced by the target word, which was displayed for 250 ms. For the 150 ms condition, there was a 1200 ms inter-trial interval; for the other two delay conditions, this interval was 500 ms. The participants were timed from the offset of the display of the target word to the push of the response button. The materials were presented on a computer running Superlab 2.0 software.

Table 1
Response latencies for affirmative-related and negative-related targets following the three sorts of primes, in the three interval conditions (+S.E.)

Condition (ms)	Control prime		Affirmative prime		Negative prime	
	Aff[a]	Neg	Aff	Neg	Aff	Neg
150	351 (11)	335 (11)	310* (12)	361 (15)	333 (14)	347 (12)
500	317 (9)	304 (10)	288* (8)	331 (15)	296* (9)	324 (10)
1000	363 (11)	373 (13)	330* (10)	379 (11)	359 (9)	359 (12)

Note. Entries marked with (*) indicate a reliable difference between the response latencies in the experimental condition and the control condition for that target word.

[a] Aff = Affirmative-related target; Neg = Negative-related target.

3. Results

The data of three participants were discarded because they answered only two of the six comprehension questions correctly. The data of another six participants were discarded because they failed to follow the instruction to press the spacebar following each statement. As errors, we included incorrect lexical decisions, reaction times that were more than 2.5 standard deviations above the mean for each subject, and extreme reaction times (>1500 ms). Response latencies were standardized after extreme response latencies were removed. Errors accounted for 5.1% of the data, and were removed from the response time analyses.

As a validation check, we first examined the reading times for the affirmative and negative metaphors. As expected, negated sentences were read more slowly than affirmative sentences in each of the three interval conditions, in all analyses by items and by subjects ($ps < .05$).

The response time data for all experimental conditions are presented in Table 1. These data are summarized in Figs. 1 and 2 in terms of difference scores, where positive values represent facilitation relative to baseline levels and negative values represent slower response times relative to baseline levels. Consistent with the view that negations are initially represented in terms of their corresponding affirmatives, affirmative-related targets were facilitated following both affirmative and negative assertions at the two shorter delay intervals, 150 and 500 ms. Negative-related targets were not facilitated at any of the three time intervals after negated metaphors.

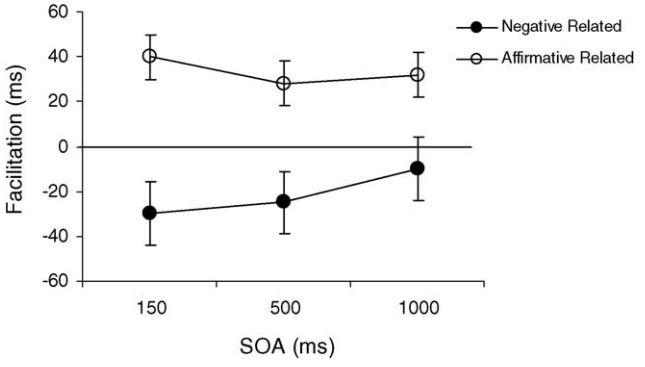

Fig. 1. Facilitation of affirmative-related and negative-related targets following affirmative metaphors (+S.E.).

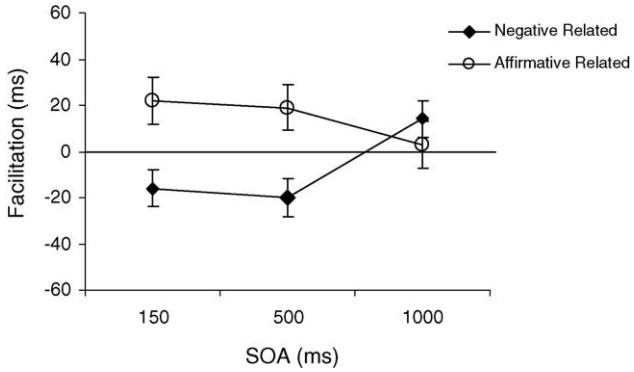

Fig. 2. Facilitation of affirmative-related and negative-related targets following negated metaphors (+S.E.).

We analyzed the data in three steps. First, we analyzed responses to the two types of target words after affirmative metaphors—this served as a validation check for the method: affirmative-related targets should be facilitated, and negative-related targets should not. We then analyzed responses to the two types of targets after negative metaphors. Finally, to see the relation between affirmation and negation we compared responses to target words after affirmative and negative metaphors.

3.1. Effects of affirmative metaphors

To examine these effects we first entered the mean response times into a 3 (Delay interval: 150, 500, 1000 ms) × 2 (Prime: affirmative, control) × 2 (Target: affirmative-related, negative-related) ANOVA. In the subjects analysis (F_s, t_s), delay interval was a between-subjects factor and type of prime and target were within-subjects factors. In the item analysis (F_i, t_i), all factors were within items. Note that the units for analysis in the item analysis are the 64 experimental probes in the study. There was a main effect of Target; affirmative-related targets were responded to faster than negative related targets, $M = 326$ ms versus 345 ms, $F_s(1, 81) = 13.5$, M.S.E. = 28,367, $p < .001$; $F_i(1, 31) = 4.12$, M.S.E. = 38,247, $p < .05$. This was modulated by a reliable Prime X Target interaction: affirmative primes primed affirmative-related targets (facilitation = 33 ms) but not negative-related ones (facilitation = −21 ms); $F_s(1, 81) = 36.9$, M.S.E. = 59,338, $p < .001$; $F_i(1, 31) = 22.5$, M.S.E. = 66,818, $p < .001$. The 33 ms facilitation for affirmative targets was reliable, $t_s(83) = 5.3$, $p < .001$; $t_i(31) = 5.56$, $p < .001$. The slowdown for negative targets was also reliable, $t_s(83) = 2.65$, $p = .01$; $t_i(31) = 2.1$, $p < .05$. There was no interaction with delay interval, $F_s < 1$; $F_i < 1$, suggesting that the relative accessibility of affirmative-related and negative-related terms did not vary over time. These data serve as a manipulation check for the method, and show that participants were sensitive to the contents of the statements. Affirmative-related targets were consistently facilitated; negative-related targets were not.

3.2. Effects of negative metaphors

We conducted a similar analysis to examine the effects of negative metaphors (see Fig. 2). Negative primes facilitated responses to affirmative-related targets (facilitation = 14 ms), but not to negative related targets (facilitation = −8 ms, *ns*), as indicated by the reliable Prime × Target

interaction, $F_s(1, 81) = 7.2$, M.S.E. = 10,443, $p < .01$; $F_i(1, 31) = 4.2$, M.S.E. = 9977, $p < .05$. The 14 ms facilitation for affirmative-related targets was reliable, $t_s(83) = 2.07$, $p < .05$; $t_i(31) = 2.09$, $p < .05$. However, the two-way interaction was further modulated by a reliable three-way Delay interval × Prime × Target interaction, $F_s(2, 81) = 3.5$, M.S.E. = 5090, $p < .05$; $F_i(2, 62) = 3.2$, M.S.E. = 5900, $p < .05$, see Fig. 2 and Table 1.[6]

As Fig. 2 shows, negated metaphors facilitated affirmative-related terms in the initial stages of processing, but not in the later stage. Furthermore, at no point during the comprehension of negative metaphors was there facilitation for both affirmative-related and negative-related targets at the same time. These results suggest that in the early stages of comprehension, negative metaphors are represented as affirmatives. Later, the representations of the two forms diverge.

3.3. The relationship between affirmation and negation

The two analyses suggest that affirmative and negative assertions give rise to similar representations early in processing. We conducted a third analysis to examine responses to affirmative-related and negative-related targets after affirmative and negated metaphors. Excluding response times following control primes, we examined response latencies following just affirmative and negative primes by conducting a 3 (Delay interval) × 2 (Prime: affirmative, negative) × 2 (Target: affirmative-related, negative-related) mixed ANOVA. We found that response times to affirmative-related targets were faster after affirmative metaphors than after negative metaphors ($M = 310$ ms versus 330 ms), and responses to negative-related targets were faster after negative metaphors than after affirmative metaphors ($M = 343$ ms versus 356 ms). This resulted in a reliable Prime × Target interaction, $F_s(1, 81) = 7.57$, M.S.E. = 19,994, $p < .01$; $F_i(1, 31) = 7.2$, M.S.E. = 25,475, $p < .05$. There was also a main effect of target, because responses to affirmative-related targets were faster than negative-related targets, $F_s(1, 81) = 42.9$, M.S.E. = 73,235, $p < .001$; $F_i(1, 31) = 9.6$, M.S.E. = 86,551, $p < .01$. However, recall that affirmative-related targets were more related to the meaning of the affirmative metaphors than negative-related targets were related to the meaning of negative metaphors. This analysis shows that affirmative and negative statements prompted different representations so that the representation of a situation was more accessible when it was affirmed than when it was denied. The three-way interaction with delay interval was not reliable ($F_s < 1, F_i = 1$), but separate analyses of each of the delay intervals revealed that the Prime X Target interaction was reliable only in the 1000 ms delay interval condition. In that condition responses to affirmative-related targets were faster after affirmative primes than after negative primes ($M = 330$ ms versus 359 ms) but responses to negative-related targets were faster after negative primes than after affirmative primes ($M = 359$ ms versus 379 ms), $F_s(1, 27) = 9.1$, M.S.E. = 16,572, $p < .01$; $F_i(1, 31) = 8.9$, M.S.E. = 16,890, $p < .01$.

Finally, if understanding negative statements is more difficult than understanding affirmatives, error rates for targets following negative and affirmative metaphors should differ. We combined the error data from the three delay conditions and entered them into a 3 (Delay interval) × 2 (Prime) × 2 (Target) mixed ANOVA. The ANOVA yielded a reliable effect of prime, $F_s(1, 80) = 3.91$, M.S.E. = 1.26, $p < .05$, $F_i(2, 124) = 2.9$, M.S.E. = .001, $p < .05$. Participants made more errors following negative statements (2.6%) than following affirmative ones (1.9%).

[6] The separate analyses of each of the ISI conditions revealed the following results. For the 150 ms condition: Prime × Target interaction, $F_s(1, 19) = 4.22$, M.S.E. = 7120, $p < .05$, $F_i(1, 31) = 2.87$, M.S.E. = 7344, $p = .1$. For the 500 ms condition: Prime × Target interaction, $F_s(1, 35) = 8.12$, M.S.E. = 13802, $p < .01$, $F_i(1, 31) = 11.7$, M.S.E. = 12975, $p < .01$. For the 1000 ms condition: no reliable effects, Prime × Target interaction non-reliable ($F_s < 1$).

These results support the notion that comprehension of negation is more difficult than affirmation. There is also no indication in the error data of a speed-accuracy tradeoff, because response latencies after negative primes were not faster than response latencies after affirmative primes.

3.4. The relationship between metaphors and irony

Metaphors are often used to express irony as they are well suited for conveying exaggeration, e.g., *The train to Boston was a rocket* (see Colston and Gibbs, 2002). An ironic reading of an affirmative metaphor could increase the accessibility of terms related to its negation, e.g., *slow*. Irony can also be expressed through negation, via litotes. Litotes are figures of speech where the negation of a predicate is used to emphasize the opposite affirmative of that predicate, as in *This cake is not bad* which implies that the cake is very good. A negated metaphor, e.g., *Her marriage wasn't an anchor* can be understood as expressing a very shaky marriage (see Giora et al., 2005b, for an extended discussion of irony and negation; see Pexman et al., 2000, for factors that prompt ironic readings in metaphors). It follows that an ironic reading of affirmative metaphors may lead to greater facilitation of negative-related terms, and an ironic reading of negative metaphors may also lead to greater facilitation of negative-related terms. This point is particularly relevant to our study, as statements can be interpreted as ironic independent of context (Giora et al., 2005b).

To examine this issue we asked 16 new participants to rate how ironic the affirmative and negative metaphors seemed to them on a scale of 0–6, where 0 stood *for not at all ironic*, 3 for *somewhat ironic* and 6 for *definitely ironic* (see Appendix C for instructions and method). We then split the affirmative metaphors and negative metaphors into low and high irony statements, and examined whether the degree of irony affected the facilitation of affirmative- and negative-related targets (i.e., their accessibility versus baseline). For affirmative metaphors the mean irony ratings for the low and high irony statements were 1.2 and 2.8, and for negative metaphors they were 1.3 and 2.7. These analyses were an extension of the analyses reported above for the affirmative and negative metaphors, but included level-of-irony as an additional factor. The analysis of affirmative metaphors revealed the same findings reported above (see section 3.1). More important, level of irony did not yield a main effect, nor an interaction with the other factors.

However, a different picture emerged for negative metaphors. For the less ironic negative metaphors (e.g., *Some workers are not robots*) the data indicated an initial accessibility of the affirmative meaning, followed by construction of the negative meaning; affirmative-related targets demonstrated decreased accessibility over time, whereas negative-related targets demonstrated increased accessibility over time (see Fig. 3).

For the more ironic negative metaphors, a different pattern emerged: meaning generation seemed to take longer (see Fig. 4). At 150 ms SOA, neither target-type was facilitated. In the later stages of comprehension, the affirmative meaning was accessible (at 500 ms) and then reduced (at 1000 ms). However, in contrast to the less-ironic metaphors, these metaphors did not show accessibility for negative related targets at 1000 ms SOA (see Fig. 4). A statistical analysis confirmed these observations. When the level of irony was introduced as an additional variable to the statistical analysis, we again observed an interaction between the delay interval and the facilitation for negative-related and affirmative-related targets (as reported in section 3.2). However, the facilitation seen for the two sorts of targets over time depended on the level of irony, $F_i(2,\ 60) = 3.8$, M.S.E. = 13,908, $p = .027$. This interaction reflects the difference in the magnitudes of facilitation seen in Figs. 3 and 4.

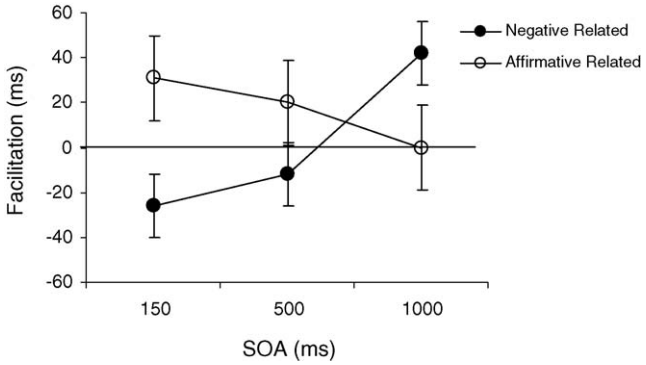

Fig. 3. Facilitation of affirmative-related and negative-related targets following low-irony negated metaphors (+S.E.).

To better understand this interaction we separately analyzed the less- and more-ironic negative metaphors. For the less ironic negative metaphors (Fig. 3), the facilitation for positive and negative related targets varied as a function of SOA, $F_i(2, 30) = 5.67$, M.S.E. = 21,149, $p = .008$. Affirmative related targets showed decreased facilitation as the SOA increased, though the linear trend was not reliable; $F_i(1, 15) = 1.2$, M.S.E. = 7399, $p = .29$. Negative related targets demonstrated increased facilitation as the SOA increased and this linear trend was reliable, $F_i(1, 15) = 7.26$, M.S.E. = 37,536, $p = .017$. Post-hoc tests revealed that at 1000 ms, negative-related targets showed a reliable facilitation of 42 ms, $t(16) = 2.15$, $p < .05$. The analysis of the more ironic metaphors revealed a different pattern of results (see Fig. 4). Facilitation for positive and negative related targets did not vary across SOAs and the interaction was not reliable, $F_i(2, 30) = 1.15$, M.S.E. = 4105, $p > .3$.

The results of the irony analysis suggest that the accessibility of an ironic reading in negative metaphors affected the facilitation of negative-related and affirmative-related targets. However, the accessibility of an ironic reading in affirmative metaphors did not affect the facilitation of these targets. Contrary to our prediction, we found that it were the less-ironic negative metaphors that better primed negative-related targets. However, it is also possible that the more ironic negative metaphors take longer to comprehend, and that they too facilitate negative-related terms once they are comprehended. Probing at later time points could evaluate this possibility.

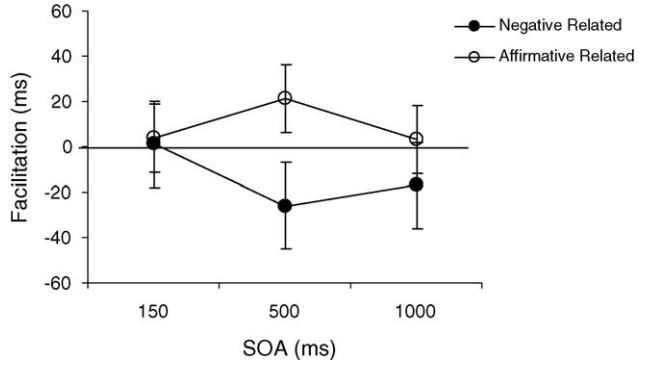

Fig. 4. Facilitation of affirmative-related and negative-related targets following high-irony negated metaphors (+S.E.).

4. Discussion

We examined the online comprehension of negated predications in the domain of metaphors. We can summarize the main findings as follows: first, negation seemed to take effect some time between 500 and 1000 ms from the time the negative sentence had been read. Until that point only the counterfactual (affirmative-related) representation was accessible. Second, only at 1000 ms did we find a reliable dissociation between the representations of affirmation and negation.

It is important to note that the relatively slow integration of negation was not due to any difficulty in comprehension of the embedded (i.e., counterfactual) affirmative proposition. On the contrary, we found that terms related to the affirmative meaning of the metaphor were accessible *immediately* after reading the affirmative metaphors, indicating that the affirmative meaning was arrived at immediately (cf. Blasko and Connine, 1993). Hence, the relatively slow integration of negation cannot be explained by difficulty in the comprehension of the affirmative propositions. Recall that during the study, participants pressed the spacebar once they had read the statement for comprehension. They were not instructed to read these statements quickly, and therefore the facilitation of affirmative-related targets after negative primes is not likely to be a result of insufficient comprehension times. Rather, these data reflect that negation is not immediately integrated during the construction of sentence meaning.

Affirmative and negative metaphors seemed to have had different effects on affirmative-related and negative-related targets. A detailed analysis of each of the delay-interval conditions revealed that in the initial stages of comprehension (150 and 500 ms intervals) there were no reliable differences between affirmation and negation. A reliable difference between affirmation and negation did appear but only some time between 500 and 1000 ms. The data therefore reveal two novel findings on the comprehension of negation. First, they provide the first demonstration that comprehension of negation can involve construction of the counterfactual (affirmative) meaning. Second, they show that negation reduced the accessibility of the counterfactual meaning over time. Analogous instances of suppression were reported by Gernsbacher and Faust (1991) and Gernsbacher et al. (1990, exp. 4), suggesting a mechanism that suppresses meanings inappropriate to context. We also found that participants made more lexical decision errors after reading negative statements than affirmative ones, which further supports the notion that comprehension of negations is more complex than of affirmations.

The findings are also important for what they show does not occur. First, we did not find that the factual and counterfactual meaning were accessible at the same time. This would have been manifested in joint facilitation of both affirmative-related and negative-related targets in at least one time point. Furthermore, another possibility is that in early stages of comprehension, negation would direct attention to the counterfactual possibility—even beyond that prompted by affirmation. We did not find this pattern. The operation of syntactic negation is therefore different than that of consciously controlled suppression, which results in increased accessibility of the negated element (e.g., Wegner et al., 1987).

Our initial examination of the possible effects of irony on the comprehension of negation showed that for this set of statements, irony might determine how quickly a negative-related representation is constructed. Although the range of ironicity ratings for our materials was rather limited, we found that the less ironic statements facilitated negative-related meanings by 1000 ms, whereas the more ironic ones did not. However, in contrast to previous research on irony (Giora et al., 1998), the more ironic affirmative statements did not evoke joint facilitation

of both affirmative-related and negative-related terms. Our investigation of the effects of irony is preliminary, and further research may indeed find that when negation affords an ironic reading in context (e.g., *I'm, sorry I'm late . . . My train was not a rocket*), both negative- and affirmative-related terms would be jointly accessible.

In this study, we have examined attributive statements based on metaphors. We have also reviewed previous studies that have focused on expressions referring to the presence or absence of entities in a situation model (e.g., Kaup, 2001). There remain, however, contexts in which negation may well be used differently. In some contexts, e.g., ''My cousin has no cat'', or ''One regular burrito and one with no sour-cream'', the combination with *no* is a nominal rather than an absence relationship (viz. My cousin doesn't have a cat; A burrito without sour cream; Langacker, 1987, p. 134). Furthermore, negation may be used in ways that are not truth-functional. For example, it may be used metalinguistically: ''The CIA doesn't 'whack' (=kill) any pinko troublemakers—it neutralizes anti-American influences'' (Yoshimura, 1997). When used metalinguistically, negation does not refer to a counterfactual situation, but negates a certain use of discourse. It is quite possible that in such cases negation would also serve to decrease the accessibility of the 'affirmative-related' meaning, however, the exact manner in which this occurs may vary with the specific sort of statement that is negated. As mentioned earlier, one factor that is likely to affect the processing of negation is the availability of an inference afforded by the negation. Prior research has shown that when negation affords an inference, people are less likely to recall negation as affirmation (Mayo et al., 2004; Hasson et al., 2005). Though those studies employed an offline memory measure, future research employing online methods might reveal that when negation offers an inference (e.g., *This person is not a liberal*), the accessibility of affirmative-related meanings is reduced more quickly, and the accessibility of the negation-related meanings is made available more quickly.

Our examination has focused on the mental representations that are constructed relatively shortly after the comprehension of negation. We have not examined the effects that negation might have on the processing of subsequent discourse units. Jordan (1998) suggests that negation serves an important discourse function as it introduces both a topic and its cancellation into discourse. To the extent that negation introduces more topics into discourse than does affirmation, the difference between the two forms may well be observed in people's comprehension of the discourse which follows the negation (cf. Levine, 2002).

5. Conclusion

We have demonstrated that negation is a linguistic device that can prompt consideration of alternative possibilities, and induce changes in the accessibility of those possibilities over time. We have also shown that negation differs from affirmation in that negation reduces the accessibility of the affirmative representation at later stages of comprehension. Our investigation suggests that the operation of linguistic devices such as negation may be best understood by studying the ways in which representations of statements develop and change over time.

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Appendix A. Do metaphor vehicles prime lexical decision targets?

The purpose of this validation study was to determine whether or not the vehicles of the metaphors used in the main experiment primed affirmative-related and negative-related targets. If they do, then the results of the experiment could be attributed to lexical priming rather than to the meaning of the affirmative and negated metaphors. Conceptually, this study was designed to be as similar as possible to the main experiment. In that study, participants read a sentence and then made a lexical decision. In this priming experiment, they read the vehicle of the metaphor and then made a lexical decision to a relevant target word.

A.1. Method

A.1.1. Participants

Twenty Princeton Undergraduate students participated to fulfill a psychology course requirement. None of these participated in the main experiment or in any of the norming studies.

A.1.2. Materials and design

The materials consisted of the vehicles of the metaphors used in the experiment and the affirmative-related and negative-related target words. Each target word (e.g., vicious or gentle) was presented after a vehicle prime (e.g., shark) or after a control prime (e.g., table). The design was therefore 2 (target: affirmative- or negative-related) $\times$ 2 (prime: vehicle or non-related control). The experimental items were rotated across four lists so that each list included only one of the four experimental conditions for each of the 32 items. Each list therefore contained eight items in each of the experimental conditions. Each list also included filler items in which the first word was followed by a non-word. The number of filler items was set up so that the proportion of trials in which the vehicles of the metaphors were followed by affirmative-related targets or negative-related targets was equivalent to the proportion of such trials in the experiment proper (17%). In addition, as a manipulation check, we included items for which priming should certainly occur (e.g., North–South, Glacier–Ice). These items were assigned to the lists so that half of the time the targets (e.g., South) were presented after a related word (e.g., North) and half the time the targets were presented after an unrelated word.

A.1.3. Procedure

Participants were presented with a word that they read at their own pace. They pressed the spacebar after reading the word, and 150 ms later were presented with a target string for a lexical decision. Participants were instructed to press a yes-designated key if the string is a word in English, and a no-designated key if it is not. They received feedback after each response. Participants first practiced making lexical decisions for 12 trials. At that point, the main study was initiated. The first 12 items of the study were filler items whose purpose was to bring participants up to speed, and were not analyzed.

A.2. Results and discussion

Errors and response latencies deviating by more than 2.5 standard deviations from the group mean were removed from the analysis. These accounted for 4.5% of the responses. The metaphorical vehicles did not prime the target words. Affirmative-related targets were responded-to slightly *slower* after metaphorical vehicles than after control primes (control prime:

333 ms, vehicle prime: 366 ms, $t_i(19) = 2.54$, $p < .05$; $t_s(19) = 2.28$, $p < .05$), and negative-related targets were responded-to just as fast in these two conditions (control prime: 333 ms, vehicle prime: 336 ms). Priming did occur for materials used as a manipulation check (control: 275 ms, experimental: 233 ms), and this difference was reliable by items, $t_i(23) = 2.3$, $p < .05$, and by subjects, $t_s(19) = 2.2$, $p < .05$. These data show that the results of the main experiment cannot be attributed to lexical priming.

Appendix B. Materials

No.	Affirmative and negative form	Negative-related	Affirmative-related
1	The train to Boston was a [was no] rocket.	Slow	Fast
2	That computer is a [is no] dinosaur.	New	Old
3	Some school-teachers are [not] encyclopedias.	Ignorant	Informed
4	His life was a [was no] sit-com.	Serious	Funny
5	Our congressman was a [was no] pawn.	Independent	Manipulated
6	Some surgeons are [not] butchers.	Precise	Clumsy
7	Our school is a [is no] magnet.	Ordinary	Excellent
8	My sister is a [is no] brain-surgeon.	Stupid	Smart
9	Her marriage was [wasn't] an anchor.	Shaky	Secure
10	His home was a [was no] palace.	Simple	Lavish
11	This kindergarten is a [is no] zoo.	Calm	Noisy
12	My daughter is a [is no] angel.	Nasty	Sweet
13	My lawyer was [wasn't] a shark.	Gentle	Vicious
14	Alcohol is a [is no] crutch.	Harmful	Helpful
15	My brother is [not] a rock.	Weak	Strong
16	Sometimes, money is [not] a lubricant.	Impedes	Eases
17	The news was [not] an earthquake.	Trivial	Important
18	He was [not] a yo-yo to be played with.	Earnest	Trifle
19	He's a [He's no] saint.	Evil	Patient
20	This exam is [not] a filter.	Easy	Hard
21	Some workers are [not] robots.	Flexible	Rigid
22	Hers is [isn't] a Cinderella story.	Sad	Happy
23	Some land-fills are [not] eye-sores.	Ugly	Pleasant
24	He was the [was no] king of the court.	Mediocre	Best
25	You can tell he's the new [no new] Calvin Klein.	Dull	Star
26	His girlfriend is a [is no] spice-girl.	Lifeless	Flashy
27	He was [not] a meteor in his field.	Average	Famous
28	Arrogance is [not] a disease.	Good	Bad
29	These lectures are [not] sleeping pills.	Interesting	Tedious
30	This writer is [not] a fountain of ideas.	Boring	Creative
31	In the past, my room was [wasn't] a junkyard.	Neat	Messy
32	That laboratory is [isn't] an idea factory.	Stagnant	Exciting

Appendix C. Procedure for obtaining irony ratings

The purpose of this procedure was to obtain a measure that would reflect the degree to which the affirmative and negated metaphors could be understood as ironic. We divided the 64 metaphors (32 affirmative and 32 negative) into two lists, each containing 16 affirmative metaphors and 16 negative metaphors. Sixteen participants whom did not participate in the main

experiment or in the other norming studies rated one of the two lists. The main section of the instructions was as follows:

> In the pages given to you are a number of simple statements. For each one, try to imagine what a person might be trying to get across by using that statement; why he or she said it, and then judge how ironic or sarcastic the person's remark is. Please provide this judgment by using a rating scale from 0 to 6, where 0 means ''not at all ironic or sarcastic'', 3 means ''somewhat ironic or sarcastic'' and 6 means ''definitely ironic or sarcastic''. Before you begin, please look over a few of the statements. This will give you a general feel for the types of statements you will be seeing. If you occasionally find yourself unsure about your rating, just use your best judgment. Remember, there are no right or wrong answers. We are simply interested in your intuitions. Be sure to provide ratings for all the statements.

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