Why We Simulate Negated Information: A Dynamic Pragmatic Account

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Abstract

A well-established finding in the simulation literature is that participants simulate the positive argument of negation soon after reading a negative sentence, prior to simulating a scene consistent with the negated sentence (Kaup et al., 2006, 2007). One interpretation of this finding is that negation requires two steps to process: first represent what is being negated then 'reject' that in favour of a representation of a negation-consistent state of affairs (*ibid*). In this paper we argue that this finding with negative sentences could be a bi-product of the dynamic way that language is interpreted relative to a common ground and not the way that negation is represented. We present a study based on Kaup et al. (2007) that tests the competing accounts. Our results suggest that some negative sentences are not processed in two steps, but provide support for the alternative, dynamic account.

Introduction

Recent studies by Kaup, Yaxley, Madden, Zwaan, & Lüdtke (2007) and Kaup, Lüdtke, & Zwaan (2006) have shown that processing negative sentences leads to simulation of the negated information. For example, shortly after reading, “The bird is not in the air”, people respond faster to an image of a flying bird (with stretched wings) than a resting bird. However, when a longer ISI is used (i.e. 1500ms), this simulation is replaced by a simulation of a state of affairs consistent with the negated sentence (e.g. a resting bird). Kaup and colleagues suggest that the two stages of simulation that they observe is a result of the mechanism of negation processing. The underlying theory is that language is processed with simulations. According to this theory, experiential simulation is the only meaning-related representation in language comprehension. Zwaan (2004) refers to this representation as the “Immersed Experiencer Framework”. According to this framework, all aspects of language interpretation are simulated, including abstract symbols and operators. Negation is processed with a "two-step simulation": the negated information is first simulated and then ‘rejected’, a process that juxtaposes a simulation of the actual state of affairs. The first step is faster or omitted if the negated information has already been mentioned or is strongly inferred (Lüdtke & Kaup, 2006). Thus, this model can explain the effect found in Kaup et al. (2007). It can also explain why negation is harder and takes longer to process than affirmative sentences, and that context affects the ease of negation processing.

We suggest an alternative explanation for this effect which emerges from thinking about language in a dynamic, use-oriented way. In this paper, we propose that the negated information has been found to be simulated in these previous studies, not because

it is the first step in the process of representing the content of the negated sentence, but because negation can trigger a process similar to presupposition accommodation. Here, we present a study which tests the two accounts of previous effects.

The Pragmatics of Discourse, Relevance and 'Questions Under Discussion'

There is long-standing acceptance of a distinction between having access to the meaning of a sentence and understanding how the sentence is being used for a broader discourse or conversational purpose. It is also widely recognised that the semantic properties of a sentence affect this more pragmatic level of discourse interpretation (Clark, 1996; Grice, 1989; Stalnaker, 1978). There is growing evidence that accessing an interpretation of a segment and inferring the purpose of the discourse on the basis of shared assumptions are processes that co-occur in incremental processing (e.g. Brown-Schmidt, Gunlogson, & Tanenhaus, 2008). Thus, when we collect time-sensitive data from comprehension tasks, we should be aware that our results may not only be the product of a process of representing an interpretation of the sentence but also a process of representing how that content might be related to a broader purpose. This observation is particularly pertinent since understanding discourse often yields more inferred information than is available from the input stimuli itself (Grice, 1989; Hobbs, Stickel, Appelt, & Martin, 1993). One area in which enrichment can occur is in the domain of what is commonly assumed, or 'common ground' (Lewis, 1979; Stalnaker, 1975; Clark 1996). Recent dynamic theories of pragmatics posit that common ground includes not only facts that are taken for granted but structures that constrain upcoming relevant contributions. In this paper, we adopt a widely used practice of describing how relevance is achieved in terms of 'Questions

Under Discussion' (QUDs – see Ginzburg, in press; Roberts, 1996; van Kuppervelt, 1996). The general idea is that a discourse segment addresses one or more prominent QUDs. Importantly, the relative prominence of QUDs changes as discourse unfolds and may be adjusted via a mechanism of accommodation, which retrospectively updates the set of QUDs in response to features of the utterances produced. Ginzburg (in press) argues that even discourse-initial segments that are apparently 'apropos of nothing' involve accommodation of a QUD, often determined by what Ginzburg calls the *genre* of the discourse.

We propose that the design of psycholinguistic experiments should take account of this dimension of the pragmatics of discourse comprehension. In particular, we believe that stand-alone sentences that are often presented to participants in a comprehension task will trigger a process of context accommodation that includes not only information required to represent what state of affairs the sentence describes, but also information which situates the segment in a common ground that motivates the tokening of that segment, described here in terms of QUDs. When faced with an experimental sentence in isolation, and no other information, the prediction is that participants will use any cues in the linguistic input to project likely QUDs. In the case of negative experimental items, our hypothesis is that, in the absence of any other contextual stimuli (see Nieuwland & Kuperberg, 2008), participants will project positive questions as the most likely prominent QUD. That is, given an item like, 'The bird is not in the air', participants will tend to project a positive QUD like, *Is the bird in the air?* rather than a negative QUD like, *Is the bird not in the air?*. This prediction is based in part on the long-standing view that negation requires specific contextual motivation (Wason, 1965). In terms of the

dynamic theories mentioned above, this means that negation normally follows a prominent QUD querying either the positive or negative proposition. Additionally, based on the fact that negative questions are marked (Huddleston & Pullum, 2002), we assume that positive questions are more frequent than negative questions and hence more likely to be accommodated in the absence of any other contextual evidence. It follows then that the effect found in Kaup et al. (2007) mentioned above could be an artefact of the task: The finding that the positive argument of negation is first simulated could be the result of accommodating a positive QUD rather than the result of a necessary part of the process of interpreting a negative sentence.

Our pragmatic account of these previous results is based only on the idea that comprehenders always represent the content of an utterance in the context of a common ground representation which includes information that makes the contribution relevant (described here in terms of QUDs). This proposal is independent of any theory or model of how we represent content for sentences containing negation. Kaup and colleagues (2006, 2007) propose a model of how sentence content is represented. In the case of negation, the negated content is represented separately in an 'auxiliary representational system' and prior to any representation of a state of affairs consistent with the negated sentence (Kaup et al., 2007: 987; Kaup et al., 2006: 1046). It is proposed that this two-stage process occurs so that the negated content can be 'rejected'. As we argue below, the meaning of negation does not require any such 'rejection' process to occur. Thus, according to the experiential view, representing the positive argument is a necessary stage in processing negation, while on the pragmatic account, it is not necessary as there are possible contexts where a negative QUD is being addressed.

The present study was designed to differentiate these two accounts (two-step simulation processing *versus* pragmatic accommodation). We used a similar paradigm as in Kaup et al. (2007), but tested simple negative sentences and cleft sentences with negative clauses. For example, “Mike didn't iron his shirt” and “It was Mike who didn't iron his shirt”, respectively. Participants saw an image of an ironed shirt or a crumpled shirt after reading either sentence, and had to decide if the item (shirt) has been mentioned in the preceding sentence.

Clefts are known to be presupposition triggers (Levinson, 1983). The example sentence has the presupposition, “Someone didn't iron his shirt”. According to the pragmatic theories discussed above, an experimental item containing such a cleft sentence would lead to the accommodation of this presupposition and should make a negative QUD, *Who didn’t iron his shirt* most prominent (see Roberts, 1996; Ginzburg *in press*). So, if our proposal is correct, the participants would accommodate a positive QUD (*Did Mike iron his shirt?*) for the simple negative sentence and a negative QUD for the clefted sentence. If we assume that presuppositions or QUDs, like statements, give rise to simulated representations consistent with their content, we should replicate the finding in Kaup et al. (2007) on the simple negative sentences, but see a reversed effect on cleft sentences. That is, participants should respond faster to an ironed shirt than a crumpled shirt after reading, “Mike didn't iron his shirt”, but should respond faster to a crumpled shirt than an ironed shirt after reading, “It was Mike who didn't iron his shirt”.

However if the reaction time patterns for the two types of sentences are the same, it will support Kaup et al.’s theory. As we understand it, their two-step model predicts that negation is treated in the same way for simple and cleft sentences: in order to

represent the content of the negative sentence, the positive argument needs to be first represented and then rejected.

Method

Participants

Forty native English speakers from the undergraduate population of University College London were paid to participate in the study.

Materials and Design

Twenty-eight experimental items were constructed, pairing a single sentence with a colour picture. All experimental sentences included a negative operator (e.g. *didn't*) and could either be clefted, as in, *It was [Character] who didn't VP*, or non-cleft, as in, *[Character] didn't VP*. VP describes the physical state of an object, which in this negative construct implies a shape that is at odds with that implied by the alternative affirmative construct. For example, "Jane didn't cook the spaghetti" implies that the spaghetti is uncooked, while its alternative affirmative form would imply that the spaghetti *is* cooked. Experimental pictures were available in two versions for each item (so fifty-six experimental pictures were used in total), with each version depicting the object in its different physical states (e.g. spaghetti, either cooked or raw), as described by the corresponding experimental sentence. Thus, one version shows the implied shape of the negative sentence (match), and the other the mismatch shape. Half the experimental sentences were paired with a picture that matched the described physical state of the object and half were paired with a picture that mismatched the described

physical state of the object. Table 1 provides an example of such experimental sentences and the associated visual displays.

In addition, fifty-six filler items were used. These filler items included fourteen negative sentences and forty-two affirmative sentences. As with the experimental sentences, half were clefted (e.g. “It was Alice who broke the vase”), while the other half were non-cleft (e.g. “David washed his car”). All negative fillers were followed by an unrelated picture target (requiring a ‘no’ response). For affirmative sentences, twenty-eight were followed by a picture depicting the mentioned object (requiring a ‘yes’ response), and the remaining fourteen by an unrelated picture (requiring a ‘no’ response).

Table 1: Example experimental sentence and the associated visual displays, as labelled.

	Match	Mismatch
Clefted: *It was Jane who didn't cook the spaghetti* Non-cleft: *Jane didn't cook the spaghetti*		

One version of each sentence-picture pair was assigned to one of four presentation lists, with each list containing twenty-eight experimental items. Each list contained one of the four possible versions of each item (2 (clefted/ non-cleft) x 2 (match/ mismatch)), blocked to ensure that they were evenly distributed among the fifty-six fillers. Each participant only saw each item once, in one of these four lists. Participants’ task was to decide whether the object in the picture had been mentioned in the preceding sentence. All experimental trials required a ‘yes’ response. Finally, comprehension questions

followed twenty-eight trials (9 experimental) and were constructed such that participants needed to understand the whole sentence rather than simply focussing on the meaning of the noun.

Procedure

The experiment was conducted on an IBM 14" laptop using E-Prime software. Each trial began with the presentation of a single sentence and participants were instructed to press the space bar as soon as they finish reading this sentence. A centrally-located fixation cross then appeared for 250ms, followed by an image (approx 3 inch by 3 inch) in the centre of the screen. The participant responded to indicate whether the object had been mentioned in the preceding sentence or not ("1" for yes and "0" for no). Comprehension questions (if applicable) appeared after the participant had responded to the image and again required yes/ no responses (with the same keys). All participants were told that response time and accuracy were measured, so they should make the decisions on images as quickly and correctly as possible and completed a short practice block at the start of the experiment. The entire experiment took approximately 15 minutes to complete.

Results and Discussion

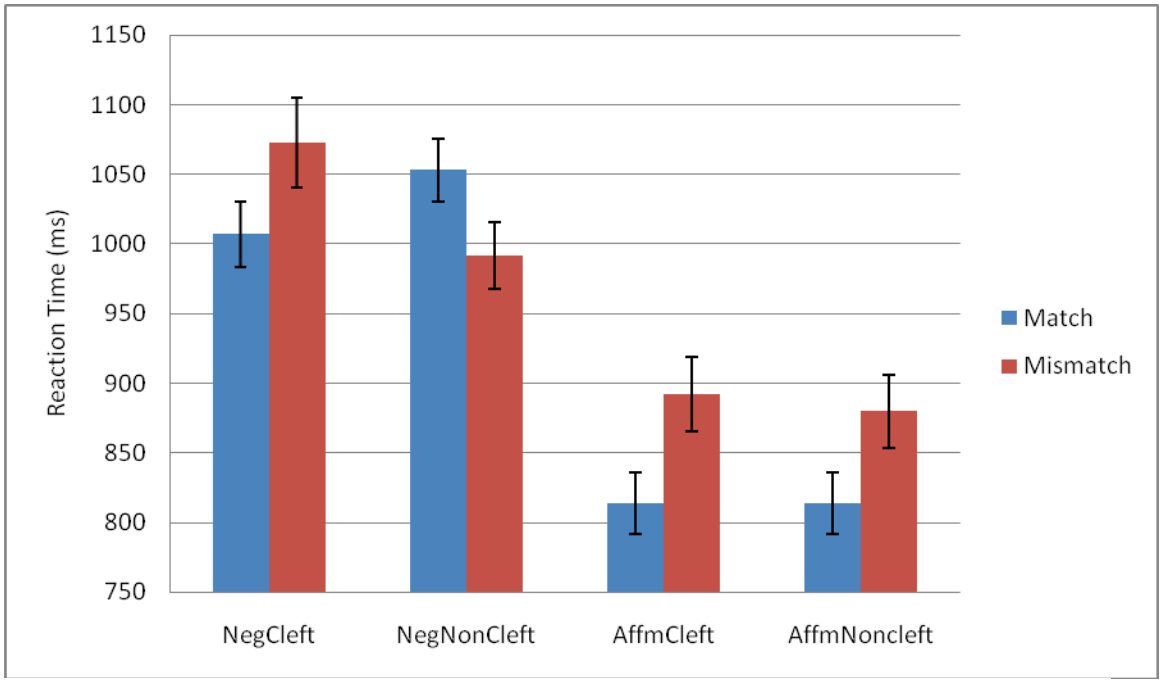
Analyses were performed on image response times. Prior to analysis all response times longer than 3000ms or shorter than 300ms were eliminated. After converting to Z scores, outliers were detected and eliminated using a Z score cut-off of 3.29 ($p < 0.001$). This eliminated 2.1% of the data. Mean reaction times are presented in Figure 1. All participants scored at or above 80% accuracy on the comprehension questions.

We performed a 2 (cleft/ non-cleft) x 2 (match/ mismatch) x 4 (lists) ANOVA with Clefting and Match as the repeated measures factors and List as a between factor. Analyses were performed both by participant (F_1) and by item (F_2). The mean image response accuracy was 95.5%, SD=0.21, meaning that participants accurately responded to the sentence-picture pairs. Results from the ANOVA showed no main effects of Clefting [Fs < 0.55] or Match [Fs < 1.88]. Also List did not interact significantly with any other variables [All Fs < 1.81].

However, the results did reveal a significant interaction between Clefting and Match [$F_1(1,36) = 6.04$, $p < 0.02$, ${}_p\eta^2 = 0.14$; $F_2(1,27) = 7.54$, $p = 0.01$, ${}_p\eta^2 = 0.22$][1]. Analysis of the simple main effects revealed that following non-cleft sentences, responses were significantly faster when the image mismatched ($\bar{x} = 992$) the implied shape in the negative sentence than when it matched ($\bar{x} = 1054$) [$F_1(1,39) = 4.02$, $p < 0.05$; $F_2(1,27) = 5.05$, $p < 0.03$]. This result replicates Kaup and Zwaan (2007)'s findings. However, following cleft sentences, the pattern was reversed. Responses showed a trend (significant by participants) where responses were slower when the image mismatched ($\bar{x} = 1074$) the implied shape in the negative sentence than when it matched ($\bar{x} = 1007$) [$F_1(1,39) = 4.33$, $p < 0.04$; $F_2(1,27) = 0.1$, $p = 0.76$].

Figure 1: Reaction times for the four experimental conditions (Note: data for a follow-up study testing affirmative versions of these items are presented alongside). Error bars represent standard errors.

[1] Strength of association is reported in terms of partial eta-squared (${}_p\eta^2$).



Taken together, the results suggest that 250ms after a cleft negative sentence, a mental image implied by the negated sentence is more active than the image implied by the alternative affirmative sentence. There is a reverse pattern for non-cleft sentence. This means that when processing a cleft negative sentence, participants didn't first mentally picture the shape which is to be negated (rejected). This result is not predicted by the two-step model for negation processing. Based on this theory, there should be no interaction between cleft/non-cleft and match/mismatch.

In the cleft condition, the faster response to the matching images suggests that participants are immediately accommodating the negative QUD, as predicted by the dynamic pragmatic account. However, it has been suggested to us that, due to the fact that cleft sentences do not focus on the negative predicate, participants might not really process the negation in this condition. In that case, the faster response to the match

images may have arisen due to properties of the images, for example the match images may have simply been easier to recognise.[2]

In order to control for the potential effects of image, we ran a follow-up study testing a new set of forty participants, but this time we replaced the negative sentences with affirmative ones (e.g. "Jane cooked the spaghetti" and "It was Jane who cooked the spaghetti"). Fillers were also adjusted accordingly to balance the negative and positive sentences of the two types. Mean reaction times are presented in Figure 1. Outliers were detected and removed as described in the main experiment. The results showed a main effect of Match, where participants were significantly faster to respond to images when they matched the sentence's affirmative meaning (e.g. "[Jane/ It was Jane who] cooked the spaghetti", followed by an image of cooked spaghetti) compared to when they mismatched [$F_1(1,36) = 14.51$, $p < 0.01$, ${}_p\eta^2 = 0.29$; $F_2(1,27) = 6.08$, $p = 0.02$, ${}_p\eta^2 = 0.18$]. Importantly, there was no main effect of Clefting [All Fs < 0.69] or a significant Match*Clefting interaction [All Fs < 0.07] in this affirmative version of the experiment. Thus we can conclude that there is no inherent difficulty in recognising either type of image and that in the main experiment, participants were processing negation in the cleft condition.

General Discussion

The purpose of this study was to find out whether a simulation of the positive argument of negation is necessary to represent negation in comprehension or whether such simulations are triggered as a by-product of the pragmatics of discourse interpretation.

[2] We thank an anonymous reviewer for this suggestion.

The results indicate that the effect of negation on response latencies of matched or mismatched images is not due to a mandatory two-step processing mechanism for negation. As predicted by the pragmatic account, we only find evidence of positive simulations after reading a simple negative sentence, after cleft negative sentences, we find the opposite pattern. One might have thought that a cleft sentence with a negative clause should take longer to process than a simple negative sentence, due to the need to accommodate the presupposition triggered by the clefting. However, participants here were faster at recognizing pictures that matched the described situation after reading cleft sentences. This is explained on the pragmatic account where simple negative items trigger their own accommodation process.[3]

While our results pose problems for the specific model of negation found in Kaup et al (2006, 2007), we would like to stress that our results do not at all affect the broader simulationist programme (Barsalou, 1999; Zwaan, 2004) in as far as that programme explores the nature of semantic representations for language comprehension. On the contrary, we believe that the simulation approach makes an important contribution to a rich tradition in semantics beginning with David Hume and found in contemporary situation-theoretic research (Barwise & Perry, 1983). In that tradition, situation semantics has long grappled with the meaning of operators such as negation (Barwise, 1989; Cooper, 1998). One important insight that distinguishes situation semantics from

[3] Our pragmatic account differs from that proposed in Mayo, Schul & Burnstein (2004), who report interference from the positive argument of negation in so-called uni-polar items ('The shirt is not red') but not in bi-polar cases ('The door is not closed'). Mayo et al. propose that two models apply to the two different classes of negation, but this does not predict the effects we report here since our items are the same across the cleft and non-cleft conditions.

traditional possible worlds semantics is that the assertion of a negative sentence should strongly imply that there is a situation which supports this (Cooper, 1998). The findings in simulationist research on negation, including the present paper, tend to confirm this implication (i.e. for 'the bird isn't in the air', people represent a scene that provides support for the claim – like a nesting bird). However, there is nothing in the meaning of negation from a situation theoretic point of view that would mandate a two-step process for representing an interpretation of an utterance containing negation. While it is an empirical question whether people in fact process negation in two-steps, the results of the study presented here suggest that they need not.

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