Dynamic Pragmatic View of Negation Processing

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Abstract Many psycholinguistic studies have found that processing negative sentences is difficult, and often involves the representation of the positive argument. Current rejection accounts suggest that processing the positive argument is the mandatory first step of negation processing, and the difficulty of negation comes from the extra step of embedding. We argue for a dynamic pragmatic view, suggesting that even when processing a sentence without context, comprehenders retrieve contextual information such as its Question Under Discussion (QUD), using linguistic cues. Without supporting context, negation acts as a cue for retrieving and accommodating the most prominent QUD, where the truth of the positive counterpart is at issue. QUD accommodation happens incrementally and automatically, which triggers the representation of the positive argument and contributes to the extra processing cost related to negation.

Keywords Negation · Question under discussion · Pragmatics · Semantics · Sentence processing

1 Introduction

In classical logic, negation has a simple semantic meaning: it changes the truth value of a proposition. If a proposition p is true, then the negation of p is false, and vice versa. By this analysis, propositions p and $\neg p$ differ only in their truth values. However, in natural language, a negative sentence does not simply communicate the opposite of a positive sentence. Consider this example. There are streets in

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London with many small hotels. When you walk along such a street, you will see many hotel signs. If among these houses, you see a sign which says "This is not a hotel", what will you think? This sign seems superfluous. We don't put up signs to say what the house is *not*, as the list would have to be infinitely long. Upon seeing this sign, you do not just understand that the house is not a hotel, you also infer that many people have asked if it was a hotel or has mistaken it as one, and the sign is for people with such an assumption. How does negation allow us to infer such background information? What can this process tell us about the often cited difficulty with negation processing? This chapter addresses these two questions in four sections. First, we briefly review psycholinguistic findings on negation processing. Second, we survey current accounts of these findings. In the third section, we propose the dynamic pragmatic view of negation processing. In the fourth section, we present three experiments which tests competing accounts.

2 Negation Processing: Two Main Findings

Psycholinguistic studies in negation processing have reported two main findings: (1) negatives are harder to process than positives, and (2) in the early processing stage, the positive arguments of negative sentences are often (but not always) represented. For the sentence "The door is not open", its positive argument (or positive counterpart) is "The door is open".

Negation-related difficulty has been found in many tasks, including sentence verification, memory recall and logical reasoning. Studies in sentence verification either involve verifying positive or negative sentences against world knowledge (e.g. Mckinstry et al. 2008; Wales and Grieve 1969; Wason 1961), such as "An elephant is not a mammal", or verifying sentences against pictures (e.g. Carpenter and Just 1975; Clark and Chase 1972; Gough 1965; Trabasso and Rollins 1971), such as the sentence "The dots are not red" against red or black dots. In these studies, negative sentences have longer response times and higher error rates than positive sentences. Negation is also shown to impact memory. A memory recall study by Cornish and Wason (1970) showed that people remember positive sentences better than negative ones. Moreover, participants are more likely to misremember a negative sentence to have appeared in a positive form, than to misremember a positive sentence to have appeared in the negative form. In terms of reasoning, studies found that logical inferences are more difficult when negation is involved (Evans et al. 1996; Oaksford and Stenning 1992; Prado and Noveck 2006). For example, when evaluating an "if…then…" rule such as "If there is there is (not) an H then there is (not) a square" (Prado and Noveck 2006), results show longer response times and higher error rates when there is negation anywhere in the rule.

In addition to the difficulty of negation, another interesting and prevalent finding regards the role of the positive argument in negation processing. Studies (Dale and Duran 2011; Fischler et al. 1983; Hasson and Glucksberg 2006; Kaup et al. 2007a; Lüdtke et al. 2008) found that in the early processing stage (approximately between

0 and 800 ms after the offset of the stimuli), negation seems to be ignored and its positive argument is represented. In a series of studies using visual probe recognition, Kaup et al. (2007a) establish that at a short latency (250 ms), participants were faster to respond to an image consistent with the positive argument of a negative sentence than an image consistent with the truth of the negative itself. For example, immediately after reading the positive sentence "The bird is in the air" or the negative sentence "The bird is not in the air", participants responded faster to an image of a flying bird than a bird at rest. At longer latencies (between 1000 and 1500 ms after the offset of the stimuli), a reversed pattern was found for negative sentences (Kaup et al. 2006). It seems that participants first represented the positive argument of negation before representing a state of affairs that is consistent with the negative sentence meaning. ERP studies (Fischler et al. 1983; Lüdtke et al. 2008) found that certain kinds of true negatives (e.g. "A robin is not a tree") gave rise to greater N400 effects (see Lee 2016 this volume for a definition) than corresponding false negatives (e.g. "A robin is not a bird"), while the corresponding false affirmatives ("A robin is a tree") predictably gave rise to a greater N400 relative to true affirmatives ("A robin is a bird"). Fischler et al. (1983) attribute this reversal of the normal N400 effect to the fact that participants first process the positive argument of negation. In a mouse-tracking study which used true or false sentences (e.g. "Elephants are not small/large"), Dale and Duran (2011, Experiment 1) found that mouse trajectories shifted more to the incorrect direction when evaluating negative sentences than positive sentences, indicating that participants were influenced by the truth value of the positive argument. All of these results suggest that representing the positive argument may play an important role in negation processing.

While it seems that participants do sometimes represent the positive argument when processing negative sentences, many studies suggest that they do not always. In the ERP literature, Nieuwland and Kuperberg (2008) show that contextually felicitous True Negatives do not give rise to an N400 effect compared to either True Affirmatives or False Negatives. Similarly, Dale and Duran (2011, Experiment 2 and 3) indicates that the more contextual support that the items have, the less the tendency to consider the positive argument of negation. We have shown (Tian et al. 2010) that when we change the negative sentence form but not the propositional content, participants no longer respond faster to the picture consistent with the positive counterpart (we will discuss this finding in more detail in experiment 1). fMRI studies on negation (Tettamanti et al. 2008; Tomasino et al. 2010) show that while reading a positive sentence with action verbs (e.g. "grip", "clasp") activates the brain regions for motor processing, negation modulates this activity. Specifically, negative sentences tend to show decreased activation relative to positive counterparts. Giora (2006, 2016 this volume) argue that with appropriate context, negation is just as easy to process as affirmation, or even easier, when the statement is used non-literally (as a metaphor or a sarcastic comment). Also some negative sentences (constructions with negative polarity items) do not have any direct affirmative counterpart. For example, it is felicitous to say "Claire didn't lift a finger to help her brother", but not "Claire lifted a finger to help her brother". These results show that the representation of the positive counterpart does not always accompany negation processing.

3 Current Accounts of Negation Processing

Psycholinguistic findings on negation present us with two questions: (1) why are negative sentences harder to process than the positives, and (2) why is the representation of the positive argument often involved when processing a negative sentence? The literature on the theories of negation processing offer two perspectives—rejection accounts and contextual approaches.

The rejection perspective suggests that the question 2 answers question 1, that negation is difficult *because* we have to represent the positive argument first. The meaning of negation is only incorporated in a second step. This idea draws on the formal analysis of negation as an external truth-functional operator. A sentence such as "The door is not open" has the structure *not* (*the door is open*). To process the negative sentence, we must first process the positive argument. We will call these accounts rejection accounts. Rejection accounts vary in the nature of representation. Propositional accounts (Carpenter and Just 1975; Clark and Chase 1972) suggest that negative sentences are represented in a propositional format, by multiple constituents. The positive counterpart embeds under the negation operator. On the other hand, the simulation account (Kaup et al. 2007b) agrees with the idea of embedding, but disagrees with the form of representation. They follow the idea of embodied language processing that language comprehension is achieved through the construction of mental simulations. These simulations are perceptual in nature, and not propositions (Barsalou 1999; Glenberg et al. 1999; Glenberg 1997; Zwaan 2004). Kaup et al. (2006, 2007a, b) suggest that we process a negative sentence in two steps. First we represent the positive counterpart, and then this representation is rejected and replaced with one consistent with the sentence meaning if possible. For example, to process the sentence "The door is not open", we first represent an open door, and then we reject this representation and replace it with a closed door. The meaning of negation is captured by the deviation of the two representations.

Rejection accounts can explain both the extra cost of negation, and why the positive counterpart is represented. However, they are faced with at least two challenges. First, many studies found that representing the positive argument is not mandatory for negation processing, sometimes even when the sentences are presented without context. These findings are incompatible with rejection accounts. Second, rejection accounts suggest that the meaning of negation cannot be incrementally incorporated. This implication seems at odds with abundant evidence for incremental language processing. Psycholinguistic research has found that comprehenders activate linguistic and even pragmatic information as soon as cues are encountered, and use such information to form predictions incrementally (e.g. Altmann and Kamide 1999; Breheny et al. 2013; van Berkum et al. 2008). In light of the findings on incremental processing, rejection accounts must explain why negation is an exception.

As rejection accounts are challenged by incompatible data and prevalent evidence for incremental processing, a more promising perspective is the contextual approach. This approach draws attention to the importance of context for negation

processing. Without context, negative utterances have two pragmatic drawbacks: infelicity and under-informativeness. Philosophy and psycholinguistics literature have both recognized the infelicity of negative utterances without context. Russell (1948) said that, "perception only gives rise to a negative judgement when the correlative positive judgment has already been made or considered". Wason (1965) argues that negative utterances are often used to deny or contradict a positive proposition. Negative sentences out of appropriate context are often infelicitous, and therefore hard to process (in the majority of psycholinguistic research on negation, sentences are presented without context). A similar idea is voiced by Horn (1978) using Gricean maxims. Grice (1975) introduced four maxims that govern our conversational behaviours: Quality, Quantity, Relevance and Manner. Horn (1978) suggests that a negative sentence is relevant to the consideration of its positive counterpart. When the positive counterpart is not in the context, uttering a negative sentence violates the maxim of Relevance.

A second pragmatic effect is that stand-alone negative sentences are often less informative than their positive counterparts. The sentence "The girl's dress is red" has can be verified by easily imaginable states of affairs. On the other hand, the sentence "The girl's dress is not red" has a much more open-ended set of verifying states of affairs and in this respect is vague. Assuming that the speaker is being cooperative when uttering a negative sentence, the comprehender must draw an inference which justifies the apparent violation of the maxim "Be informative as is required". However if being under-informative is a reason for extra processing cost, it shouldn't apply to negative sentences with a binary predicate, the negation of which being as informative as the predicate (e.g. alive/dead, even/odd).

Current contextual approaches explain the difficulty of negation in terms of its requirement for specific context. While this line of thought seems plausible, as well as being empirically supported, it raises a number of important questions that are yet to be answered. First, negation is not alone in requiring special contextual conditions for its appropriate use. It is widely agreed that virtually every utterance contains elements that require some kind of contextual completion for its full interpretation—for instance, anaphoric or pronominal elements, tense, quantifiers and so forth. Moreover, some positive sentences require a "context of plausible assertion" just as much as negative sentences require a "context of plausible denial". That is just as much as "The door is not closed" is typically produced when "The door is closed" is at issue, "The door is open" is typically produced when the state of the door is at issue. So the first question is, what is it about the contextual demands of *negative* sentences that make them particularly difficult to process when presented out of the blue, compared to their positive counterparts? Second, as mentioned above, the positive argument of a negative sentence is often, although not always, represented during early stages of negation processing. Following the contextual approach, Nieuwland and Kuperberg (2008) suggest that with the right contextual support, the positive argument need not be represented for comprehension. Similar conclusions are drawn in Dale and Duran (2011). However, no contextual account so far explains why when lacking contextual support, the positive argument IS represented in the first place.

Taking stock, current accounts of negation processing fall into two categories: rejection accounts or contextual approaches. Rejection accounts draw on the idea that negation is an external operator on a positive proposition. The extra cost of negation comes from the extra step of embedding. However, these accounts fall short of explaining the findings that the positive argument is not always represented. Also their implication is at odds with evidence for incremental language processing. Contextual approaches focus on the cost of lack of context. They argue that with appropriate contextual support, negation is not difficult. However, these approaches haven't spelled out how the contextual requirement of negation triggers more processing cost than the positive counterpart. They also do not explain why it is that when we process negative sentences without context, we often represent the positive argument.

4 Dynamic Pragmatic Account of Negation Processing

The current contextual approach, though promising, does not provide a satisfactory explanation of why the contextual requirement of negation triggers the representation of the positive argument. To solve this problem, we turn to the dynamic semantic and pragmatic approach, which analyses meaning at a dialogue/discourse level (e.g. Ginzburg 2012; Lewis 1979; Roberts 2012; Stalnaker 1978). Natural language use is interactive. Identifying and updating contextual information plays a central role in communication. Theories on language comprehension should not be detached from the role of context. In other words, we cannot understand how a sentence is processed by treating it as an item completely independent from context.

To understand how the dynamic pragmatic approach works, it is useful to think of language use as a species of purposive interactive behaviour (Grice 1975; Clark 1976). Conversational participants interact according to specific principles to achieve goals. In a conversation, we have a general *goal* of discovering and sharing with other participants information about the world (Stalnaker 1978), as well as specific goals such as purchasing a ticket or getting directions. To do this, we *interact* by producing and comprehending utterances, following conventional (linguistic) and conversational (e.g. Gricean maxims) *principles*. Each utterance updates the context. In turn, the context can constrain the content and structure of upcoming utterances.

Traditionally both semanticists and psycholinguists have focused on those aspects of context that enable language users to infer contextual information needed to establish the content of the utterance (what proposition is being expressed). This involves finding referents for contextually dependent expressions (like pronouns and definite descriptions) and other relevant presupposed or background information. Increasingly, theoretical linguists are acknowledging an important role for another aspect of context more closely related to the interactional dimension of language. This is the source of relevance of the utterance, often described as a Question Under Discussion (QUD, see Ginzburg 2012; Roberts 2012). For example, the assertion "I am going to Paris" may address the QUD "where is the speaker going". The QUD for an assertion can be explicit in the context, but very often it is implicit and is inferred and *accommodated*

(Carlson 1983; Roberts 2012). Accommodating presuppositions and QUD have similar properties. As the former has been studied more, we will first explain presupposition accommodation, and then introduce QUD accommodation.

The presuppositions of an utterance are background beliefs that are taken for granted for a given utterance (Karttunen 1974; Lewis 1979; Stalnaker 1973, 1998; von Fintel 2004 among others). For example, "My cat is sick" presupposes that the speaker has a cat. The utterance is felicitous only if its presupposition is already entailed by the context. So it is felicitous to say "I have a cat, and it is sick", but not "My cat is sick, and I have a cat" (cf. van der Sandt 1988). However, if the presuppositions are not entailed by the context, they can be *accommodated*: the hearer can add the presupposed propositions into the context, before she updates the context with the asserted information. So if it is not part of the context that the speaker has a cat, upon hearing "My cat is sick", the hearer will first update the context with the presupposition, and then with the asserted content. von Fintel (2008: 1) describes presupposition accommodation as "the process by which the context is adjusted quietly and without fuss to accept the utterance of a sentence that imposes certain requirements on the context in which it is processed".

Question Under Discussion (QUD) refers to what is at issue at any given point of the conversation. Roberts (2012: 6) says that QUD "tells you what the discourse is "about" at that point in the discourse, and […] where the discourse is going". QUD dynamically changes with each utterance. As mentioned before, QUD is sometimes explicitly realised by the speech act of asking a question. However, very often questions are implicit, and are inferred and accommodated using linguistic or non-linguistic cues. These cues enable the hearer to reconstruct the question, and thus relate the current utterance to that question (Roberts 2012; Ginzburg 2012). An example of a QUD cue is prosodic focus. In English, prosodic focus in an assertion constrains the kinds of questions it can answer (Roberts 2012). The focused constituent is new information in the utterance, and thus it was unknown in the QUD. The constituents without focus are old information, put forward by the QUD. When the QUD is not explicitly realised, prosodic focus acts as a cue for retrieving the prominent QUD. For example, on hearing "$[\text{JOHN}]_{\text{f}}$ invited Mary for dinner." (here "John" receives prosodic focus), the hearer can accommodate the QUD "Who invited Mary for dinner?", based on the constituent in focus.

We argue that negation is a cue for retrieving the prominent QUD. Following observations from contextual approaches, negation is most frequently used when the truth of positive counterpart is at issue. Without other cues, the most prominent QUD for a negative sentence $\neg p$ is *whether p.* For example, the most prominent QUD for "The door is not open" is *whether the door is open.*[1] When this contextual question is not explicitly realised, negation triggers us to accommodate a positive

[1]Can negation triggered QUD accommodation be unified with prosodic focus triggered QUD accommodation? Hedberg and Sosa (2003) studied the intonation of negative sentences, and found that the negative morpheme or auxiliary is almost always marked with a high pitch accent, except when negation is contracted with the auxiliary "do". Therefore, when "don't" doesn't receive a high pitch accent and no other constituent is focused, negation must act as a QUD cue itself. Note that in this example, if either "the door" or "open" are focused, the prominent QUD changes. For example, if "the door" is focused, the prominent QUD becomes "What isn't open?".

QUD.[2] This process is in fact common in natural language use. A corpus study by Tottie (1991) shows that a main function of negation in natural language is denial, which can be explicit or implicit. Explicit denial is a response to an explicitly asserted proposition. In case of implicit denial, the proposition to be denied is inferred from the context. In the reported sample of 427 cases of negation in spoken English, 286 (67 %) are implicit denial (Tottie 1991: 35). This shows that we routinely accommodate QUD for negative sentences. Wallage (this volume) shows that the modern English *do*-support in negative sentences (e.g. I don't like it) was grammaticalised due to pragmatic unmarking. In Middle English, *do*-support in negatives was only used to contradict a salient positive counterpart in the discourse.

In the psycholinguistic literature, it has long been recognised that information about the context is integrated into on-line processing without delay (Tanenhaus et al. 1995). However, as mentioned above, the focus in psycholinguistics is on information relevant to satisfying presuppositions or assigning reference. In line with the recent dynamic-pragmatic turn in semantics, our view is that establishing utterance content and determining the source of relevance, or QUD, are processes that go hand in hand. Thus in cases where QUD is not already salient (as where an explicit question is asked) and QUD has to be accommodated, this process occurs incrementally. As soon as we hear "$[\text{JOHN}]_f$ …", we start constructing the QUD "who …", where the rest of the question is old information. Similarly, without other contextual information or linguistic cues, we incrementally retrieve a positive QUD soon after encountering negation. This is in line with recent findings that both accessing the linguistic coded content and inferring contextual information occur in incremental processing (Brown-Schmidt et al. 2008). QUD accommodation is also automatic. It happens when we engage in a conversation, *and* when we read speakerless out-of-context sentences in an experiment. Sentence comprehension can never be independent from context. This explains why many studies found that the representation of the positive argument is involved in negation processing. This is not because negation is processed by first representing the positive argument and then rejecting it. Rather, it is due to QUD accommodation. We predict that the representation of the positive argument is not mandatory. If other linguistic or contextual cue points to a prominent negative QUD, we will no longer represent the positive argument. In addition, we argue that the meaning of negation can be incrementally incorporated.

To put our theory to the test, we present three experiments. In experiment 1, we test our theory by looking at negation and the representation of the positive argument. In experiment 2, we use our theory to explain the often reported effect of negation on sentence verification. In experiment 3, we use a visual-world eye tracking study to study when QUD accommodation happens.

[2]Here we restrict our attention to propositions with sentential negation. Negative imperatives (e.g. "Don't enter this room"), negative questions (e.g. "Are you not coming to the party"), sentences with implicit negation ("It is unimportant") or embedded negation ("It's John who didn't come") should have different effects on context update. Some of these may require a context where the positive alternative is relevant (e.g. "It is unimportant" > whether it is important is relevant; "Don't enter this room" > the outcome of entering this room is relevant).

5 Evaluating the Dynamic Pragmatic View

5.1 Experiment 1: Negation and the Representation of the Positive Argument

Studies by Kaup et al. (2007a) have shown that processing negative sentences leads to the simulation of the negated information. In their study, participants are asked to read positive or negative sentences, and are shown a picture that matches or mismatches the sentence meaning at certain inter-stimulus intervals (ISI) after reading. Their task is to indicate whether the item in the picture has been mentioned in the sentence. For example, for "The bird is in the air", participants see either a matching picture (a flying bird) or a mismatching picture (a resting bird). Answers for both pictures are "yes", since both depict "bird", which was mentioned in the sentence. When the pictures are presented at 250 ms ISI, they found that after reading a positive sentence, participants respond faster to a matching picture than a mismatching picture. For a negative sentence such as "The bird is not in the air", the pattern is reversed. At 250 ms ISI, participants respond faster to a mismatching picture (a flying bird) than a matching one (a resting bird). However, after a longer interval (1500 ISI), participants respond faster to a matching picture for both positive and negative sentences. This shows that when processing a negative sentence, participants initially represent its positive argument. With this result, Kaup and colleagues suggest that negation is represented with two-step simulation: first a simulation of the positive argument, and then the first simulation is rejected and replaced with one that is consistent with the sentence meaning whenever possible. If a negative sentence is presented with an explicit positive context, the first simulation step is faster or omitted (Lüdtke and Kaup 2006), which explains why the processing of negation is greatly facilitated by context.

We argue that the positive argument is represented due to QUD accommodation. Without context, negation in sentences like "The bird is not in the air" acts as a cue for retrieving the most prominent QUD, where the truth of the positive counterpart "The bird is in the air" is at issue.[3] If we assume that QUD accommodation gives rise to simulated representations, just like the processing of sentences, we can explain the pattern found in the above study in terms of accommodation of a positive QUD.

We predict that if other cues in the sentence point to a more prominent *negative* QUD, participants will represent a positive QUD, and the pattern should reverse. To test this account, we conducted a study using a similar paradigm to Kaup et al. (2007a), and compared simple negative sentences and cleft negative sentences.

In English, the most common form of cleft sentence is "it-cleft", which has the form of *it* + *be* + *X* + *subordinate clause.* For example, "It is John who didn't

[3]Note that in natural language use, a simple negative sentence like "x is not y" can have other QUDs, depending on the constituent in focus, such as "which is not y", or "x is not what?". We argue that without context, participants accommodate the most likely QUD for this construction, which is "whether x is y".

iron his shirt". Clefts are known to be presupposition triggers (Levinson 1983). The above sentence presupposes "Someone didn't iron their shirt". Cleft structure also constrains the most likely QUD. In this example, the clefted constituent ("John") is the only constituent in focus, and the rest ("didn't iron one's shirt") is old information put forward by the QUD. The construction thus serves as a cue for the prominent QUD *who didn't iron their shirt.* Note that the example question is negative. We predict that when the stimulus is a simple negative sentence like "John didn't iron his shirt", participants will respond faster to a mismatching image (smooth shirt) than a matching image (crumpled shirt). However when the stimulus is a cleft negative sentence, like "It is John who didn't iron his shirt", we will see a reversed pattern. On the other hand, the two-step stimulation account should predict the same pattern for both simple and cleft negative sentences.

Experiment 1 (Tian et al. 2010) adopts a similar paradigm as in Kaup et al. (2007a). Participants read a sentence on the screen, and press a key when they finish reading. 250 ms after the key press, a picture appears. Participants then indicate whether the object noun has been mentioned in the preceding sentence. There are 28 experimental items, which are simple or cleft negative sentences. Cleft sentences are in the form of "It was [character] who didn't *VP*", for example, "It was Jane who didn't cook the spaghetti". Simple sentences are in the form of "[character] didn't *VP*", for example, "Jane didn't cook the spaghetti". Sentence predicates, such as "didn't iron his shirt", imply a unique physical state of an object. All the items have predicates such that the positive form and its negation imply two distinctive physical states. Each experimental sentence is paired with a picture that matches or mismatches the physical state of the object implied by the sentence. All experimental sentences have a "yes" answer. For an example, see Table 1. In addition, there were 56 filler items, including 14 negative sentences and 42 positive sentences. Answer polarity and cleftness are counterbalanced for all sentences.

As predicted, for simple negative sentences, responses are significantly faster when the image mismatches the implied shape (mean RT 992 ms) than when the image matches (mean RT 1054 ms), thus replicating results of (Kaup et al. 2007a). However, for cleft sentences, the opposite holds. Participants respond faster to the matching image than the mismatching image. 2 (cleft/simple) by 2 (match/mismatch) ANOVA reveals a significant interaction (see Tian et al. 2010 for details of statistical tests results). The results show that when processing a cleft negative sentence, participants do not first represent the shape which is implied by the positive argument.[4]

Experiment 1 replicates the findings of Kaup et al. (2007a). We found that shortly after reading a simple negative sentence, responses to pictures are faster when the picture mismatches the implied shape of the negative sentence than when it matches the implied shape. However, we have also shown that after reading a

[4]To control for the potential typicality effects of the images, we ran a follow-up study using the same items, but replaced all the negative sentences with affirmative ones (fillers are adjusted accordingly to balance polarity and clefting). The results show no significant interaction between match and clefting, nor any main effect of clefting. Instead, match images have faster response to mismatch images. Thus we conclude that there is no inherent difficulty in recognizing either type of image.

Table 1 Example of experimental item, experiment 1

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

cleft negative sentence, the response time pattern reversed. The results suggest that the representation of the positive counterpart is not a mandatory first step of negation processing. Rather, it is probably due to QUD accommodation. Without further contextual information, the structure of a simple negative sentence projects a prominent QUD where the truth of the positive counterpart is at issue. The accommodation of this QUD involves the simulation of the positive argument. However, in case of a cleft negative sentence, the cleft structure projects a prominent QUD that is negative. Therefore, participants no longer first represent the positive argument.

5.2 Experiment 2: Negation and Sentence Verification

There is a long tradition of research into how negative (as compared to positive) sentences are verified. This research is widely regarded as being significant for the nature of representational states involved in language processing. In these studies, participants are often asked to verify a positive or negative sentence against an image. For example, in Clark and Chase (1972), participants were shown a sentence such as (1) to (4) alongside a picture that makes the sentence true or false.

(1) The plus is above the star. (True Affirmative, abbrev as TA)

(2) The star is above the plus. (False Affirmative, FA)

(3) The star isn't above the plus. (True Negative, TN)

(4) The plus isn't above the star. (False Negative, FN)

Picture:

One consistent finding was that negative sentences cause more errors and take longer than their affirmative counterparts. This has been viewed as evidence for the idea that negative sentences are harder to process than positives. When verifying an affirmative sentence, true ones are easier than false ones (reaction times TA < FA). This is where the consistency in results ends. With negative sentences, results point in different directions. Many studies (e.g. Carpenter and Just 1975; Clark and Chase

1972) found that true negative sentences are harder than false ones, thus reporting a polarity by truth value interaction: TA < FA < FN < TN. Some studies found that true and false negatives are equally difficult: TA < FA < FN = TN (Gough 1965; Wason 1961). Yet others found that true negatives are easier than false ones (Arroyo 1982; Trabasso and Rollins 1971; Young and Chase 1971), thus reporting a main effect of polarity and a main effect of truth value: TA < FA < TN < FN.

Despite the fact that different patterns between TN and FN have been reported, current models on sentence verification generally only explain one pattern. The main effect only pattern is explained by the conversion model. Trabasso and Rollins (1971) found a main effect of polarity and truth value (TA < FA < TN < FN). They propose that negative sentences are first converted into a positive one. For example, the sentence "The door is not open" is converted to "The door is closed". The process of conversion explains the extra cost of negation. Coupled with the assumption that verification takes longer than falsification (as seen in TA < FA), they explain the main effects of polarity and truth value.

The more well-known interactive pattern (TA < FA < FN < TN) is explained by rejection accounts (Carpenter and Just 1975; Clark and Chase 1972; Kaup et al. 2005). According to them, negative sentences are represented by their positive argument and an external negation operator. In a verification task, the argument of TN is FA, and the argument of FN is TA, which is why polarity interacts with truth value. Both the propositional model and the simulation account have proposed such explanations.

Propositional models, notably proposed by Clark and Chase (1972) and Carpenter and Just (1975), assume that the content of both the sentence and picture are represented in a propositional format. For example, sentence "plus is not above star" is represented as "Not (above [star, plus])". Pictures are always represented in an affirmative format such as "above [star, plus]". It is assumed that representations for images never contain negation. If participants read the sentence first, they will use the predicate from the sentence to code the picture. So if the sentence had "below", they will use "below" to code the picture. After both inputs are coded, the two representations are compared constituent by constituent from the innermost part. The original response is set as "true". Every time a mismatch is detected, the response index switches. Response time reflects the total number of switches. According to this model, TA has no mismatch, FA and FN each has one mismatch, while TN has two mismatches (see Table 2).

The two-step simulation account (Kaup et al. 2005) disagrees with the assumption that sentence and picture are represented in propositional format. Rather, they propose

Table 2 Sentence representations and number of mismatches against picture (see above) (Clark and Chase 1972)

Type	Sentence	Representation	Mismatches
TA	The plus is above the star	Above [plus, star]	0
FA	The star is above the plus	Above [star, plus]	1
FN	The plus isn't above the star	Not (above [plus, star])	1
TN	The star isn't above the plus	Not (above [star, plus])	2

that sentences are represented with experiential image-like simulations, which can be compared with pictures. Negative sentences are processed with two stages: first a simulation of the positive argument, then this is discarded and replaced with a simulation consistent with sentence meaning (if possible). In sentence-picture verification tasks, the reaction time pattern is determined by whether the sentence representation is in the first or the second step, when it is compared with the picture. If the picture is presented alongside or immediately after the sentence, the comparison happens when the participants are still focusing on the first step of negation processing—the positive argument. In this case, the representation of FN matches the picture, and TN mismatches the picture. They assume faster reactions when two representations match then when they mismatch, predicting FN < TN and thus a polarity by truth value interaction. However, if the picture is presented with a longer delay, participants will have shifted their attention to the second stage representation—the actual situation. At that time, the representation of FN mismatches the picture, and TN matches the picture, thus predicting FN > TN and no interaction between polarity and truth value.

Both the propositional model and the simulation account explain the interaction pattern drawing on the truth-value function of negation. As negation alters the truth value of a positive argument, verifying a negative sentence can be done via first verifying the truth of the embedded positive proposition, and then switching its truth value. However, neither model can account for the diverse findings in the reaction patterns of TN and FN, and neither explains why negative sentences in general take longer to verify than positive sentences (specifically FA < FN). In the propositional model, both FA and FN involve one mismatch. In Kaup et al. (2005), the data of their probe recognition task showed that reaction times for FA and FN were roughly the same.

It seems likely that two different strategies can be used and *are* used in sentence verification tasks. The truth-functional strategy proposed by rejection accounts can explain the polarity by truth value interaction pattern in verification tasks, but models based on this strategy lack a broader applicability in language comprehension. Generally, language is processed on the assumption that a statement is true, or at least relevant. Thus, comprehension processes are geared towards representing what is the case according to what is asserted, or what follows from what is asserted in the context. Verification is a metalinguistic task that normally requires establishing what would be the case if the sentence were true, and comparing that to evidence. The same process should be followed for both positive and negative statements. We compute what the world should be like given what is asserted in a sentence (be it positive or negative), and comparing it with evidence. Based on this idea, we will not expect a polarity by truth value interaction. Rather, we should expect that true statements, whether positive or negative, take less time to verify than false statements.[5] This process should be the default strategy if participants

[5]Here we assume verification is easier than falsification. However the reason is unclear. In fact, we found that in an overt string comparison task, identifying a match is not in general easier than identifying a mismatch (Tian 2014). However, in a sentence-picture verification task, it could be that when sentences are processed first, the representation of the sentence primes the image that makes the sentence true. When pictures are processed first, it facilitates the processing of a true sentence also by priming its representation.

apply their comprehension processes while performing sentence verification tasks, as Tanenhaus et al. (1976) suggests. The default strategy can explain findings where only main effects of polarity and truth value are reported. In comparison, the truth functional strategy, proposed by rejection accounts, focuses precisely on what is *not* the case according to the assertion. It deviates from the natural comprehension process. Yet it is likely that this strategy can also be used. When and why do participants adopt the truth functional strategy? We propose that the pragmatic effect of negation is the trigger.

According to the dynamic pragmatic account, negative sentences out of context trigger the accommodation of a prominent positive QUD. For sentence such as "The star is not above the plus", its prominent QUD is whether the star is above the plus. Representing competing events simultaneously is costly (Hindy et al. 2013). In a verification task, QUD accommodation can interfere with the verification process. The verification task poses the question of whether the sentence is true, or in the case of the example, whether it is true that the star is not above the plus. By the default strategy, participants infer what should follow from what is asserted from "The star is not above the plus", namely the plus is above the star.[6] They compare this representation with the picture. However, during this process, participants also represent the positive QUD, which is in conflict with the accommodated positive QUD. This incongruence can trigger participants to adopt the truth functional strategy. Instead of representing what should follow from what is asserted, participants can use the information from the picture to answer the accommodated positive QUD, and switch the answer afterwards. We argue that the truth functional strategy is a special purpose process developed specifically for the task of verifying negative sentences against pictures.

We predict that in a traditional sentence-picture verification task, the default strategy leads to an initial main-effect-only pattern, and only later does the interactive pattern start to emerge, due to the development of the truth functional strategy. We also predict that when contextual cues project a prominent negative QUD for negative sentences, participants no longer develop the secondary (truth-functional) strategy.

To test our account, we used sentences such as "The banana isn't peeled", where the positive and the negative version of the sentence imply two distinctive physical states of the subject noun. We used different picture contexts to manipulate the polarity of the prominent QUD (see Table 3 for an example). In the one-item condition, sentences are paired with pictures with a single item, in this case a banana that is peeled or whole. In this case, the most prominent QUD for the negative sentence is positive: whether the banana is peeled. In the two-item condition,

[6]Drawing this inference also requires learning and expecting both mentioned items to be in the display, and that one is positioned above the other. This information tended to be giving in the instructions in previous studies, and participants were exposed to pictures like this in practice. However, it is likely that drawing an inference for sentences containing such "context-dependent" binary predicates is more difficult than for sentences with natural binary predicates, such as "The door isn't open".

Table 3 Experiment 2 example sentence and pictures

Example sentence	One-item picture	Two-item picture
The banana isn't peeled		
		

we created pictures each containing two items: one item that matches the predicate and another that mismatches the predicate. In this case, it could be a peeled banana and an unpeeled orange. Combining the two-item picture context with the sentence, the prominent QUD becomes *which item is not peeled.* We predict that in the one-item context, participants will first use the default strategy, and then switch to the truth-functional strategy. Thus we shall first see an initial main effect only pattern, followed by an interactive pattern. In the two-item context, participants should stick to the default strategy, thus exhibiting main effect only pattern all the way through.

Our experiment (Tian and Breheny under review) had a between-group design: one group of participants saw one-item pictures only, and the other group saw two-item pictures only. In both groups, there were 112 experimental sentences (counterbalancing polarity and truth-value), each paired with one of two pictures that make the sentence true or false. The difference is whether the picture contains one or two items. In addition, there were 28 fillers. In the one-image condition, the fillers were in the same form as the experimental sentences. In two-image condition, the fillers were in the cleft form (e.g. "It is the banana that isn't peeled"). This is to make the negative QUD salient (which one isn't peeled). Participants read the sentence first. They pressed a button when they finish reading the sentence, and then they saw a picture. They judged whether the proceeding sentence was true or false by pressing a button.

We were interested in the reaction times (RT) of true and false negatives in the two conditions, and importantly, if and how the pattern change over time. The results are as predicted. We found that in the one-item condition, there is a main effect of polarity and truth value. Overall, negatives took longer than positives and false sentences take longer than true ones. However, when splitting the responses into four quarters, we saw that FN is initially much slower than TN, but the difference drops in each quarter (RT difference FN-TN: 1st quarter 285 ms; 2nd quarter

162 ms; 3rd quarter 90 ms, 4th quarter 52 ms). This change shows an initial main effect of truth value, and an emergence of polarity by truth interaction pattern. ANOVA of quarter (1st vs. 4th quarter) by truth value on between the first and fourth quarter shows a significant quarter by truth-value interaction (see Tian and Breheny under review for detailed statistical tests results). This result fits our prediction that a polarity by truth interaction is the result of a training effect.

In two-item condition, there was a main effect of polarity and truth value. When splitting the responses into four quarters, though there were fluctuations, there was no consistent change in FN-TN over time (RT difference FN-TN: 1st quarter 157 ms; 2nd quarter 4 ms; 3rd quarter 91 ms, 4th quarter 151 ms). ANOVA with quarter (1st vs. 4th quarter) by truth value on between the first and fourth quarter reveals no quarter by truth-value interaction.

Our results show that when negative sentences are verified against a one-item image, there is a training effect. In the beginning, true negatives are verified faster than false negatives. Later on, the difference between true and false negatives diminishes. This change suggests that participants initially adopted the default strategy where they inferred the state of affairs for negative sentences. Later, participants developed the truth-functional strategy where they first verified the positive counterpart and then switched the truth index. This strategy can lead to a polarity by truth-value interaction reported in previous studies. However, in the two-item condition, there is no training effect. Participants used the default strategy throughout the experiment. Our results support the dynamic pragmatic account.

Coming back to the discrepancy in sentence-picture verification findings, our results suggest that whether we get an interactive or main-effect-only pattern can be influenced by the length of the study. In a long experiment, the pragmatic effect of negation can trigger participants to develop a task-specific strategy, thus it is more likely to yield a polarity by truth value interaction. In a short experiment, participants might stick to the default strategy, or develop the truth functional strategy relatively late in the experiment, thus being more likely to exhibit a main effect only pattern.

Can our account explain why negative sentences in general are harder to verify than positives? With the default strategy, inferring what the world should be like following a negative sentence is more costly for negatives than positives. This explains the general negation cost in the main effect only pattern. With a truth-functional strategy the accommodated positive QUD interferes with the task question. This explains the general negation cost in the interaction pattern.

This study suggests that QUD accommodation is an automatic process that occurs even when we engage in an unnatural metalinguistic task. Our next question is when QUD accommodation takes place during sentence processing and at what point the meaning of negation is incorporated. To investigate the time course of negation processing, we turn to the visual world eye-tracking paradigm.

5.3 Experiment 3: A Visual World Study of Negation Processing: When Do We Represent the Positive?

Experiment 3 investigates the timecourse of QUD accommodation during negative sentence processing, using visual-world eyetracking. In a visual-world paradigm, participants usually listen to linguistic stimuli while looking at visual scenes that are in some way related. It has been found (Cooper 1974; Tanenhaus et al. 1995) that even without any metalinguistic task, participants shift their visual attention around the scene as the linguistic stimuli unfold (for a comprehensive review on the visual world paradigm, see Huettig et al. 2011). Altmann and colleagues (Altmann and Kamide 1999, 2007) found that language-mediated eye movements are anticipatory, and they correspond to a dynamically changing representation of events. Altmann and Kamide (2007) presented participants with semi-realistic visual scenes such as a man standing next to table with an empty wine glass, a full beer glass and some distractors, while listening to a sentence such as "The man will drink all of the beer" or "The man has drunk all the wine". They found that participants shifted their visual attention to the full beer glass or empty wine glass before the onset of the critical noun "beer" or "wine". This shows that participants incrementally update their representation of events by combining linguistic with visual information.

Our study (Tian et al. under review) adopts a similar paradigm as Altmann and Kamide (2007). Here we compare positive and negative sentences in simple form (as in 5a and 5b), as well as in cleft form (as in 6a and 6b). As illustrated in experiment 1, we have seen that simple negative sentence like 5b triggers the accommodation of a positive QUD (whether Matt has shut his dad's window). Accommodating this positive QUD involves the representation of the positive counterpart. However, a cleft negative sentence like 6b projects a prominent negative QUD (who hasn't shut their dad's window). In this case, participants no longer represent the positive counterpart.

(5) a. Matt has shut his dad's window.
b. Matt hasn't shut his dad's window.

(6) a. It is Matt who has shut his dad's window.
b. It is Matt who hasn't shut his dad's window.

We constructed 40 experimental sentences in simple or cleft form. All predicates imply that the target item is in two distinctive physical states before and after the event. Note that we added words such as "his dad's" in between the verb and target noun, because studies (Altmann and Kamide 2007 experiment 1; Barr 2008) have shown that upon hearing a word, the semantic priming effect can temporarily interfere with the integration of linguistic stimuli with anticipatory event representation or contextual information. There are 40 filler sentences with the auxiliaries "will", "should have" and "shouldn't have". Overall we counterbalanced polarity and whether the sentence implied the beginning or the end of an event. Each sentence is paired with a visual scene consisting of five items: a person in the centre, a target, a competitor, and two distractors. The target represents the implied states of the noun,

while the competitor represents the opposite. For example, for the sentence "Matt hasn't shut his dad's window", the target is an open window and the competitor is a shut window. The two distractors are images of an item in two states (for example a plain bagel and a bagel with cream cheese), so that participants will not be able to predict the verb before hearing it. Participants are asked to look at the visual scene while listening to the sentence. Their eye-movements are recorded.

We are interested in if, when and for how long the representation of the positive argument is activated when hearing a simple negative (5b) or a cleft negative sentence (6b). Also we want to see if the processing of simple and cleft negative sentences are delayed compared to their positive counterparts ((5a) and (6a)), and at what point the meaning of negation is integrated. According to rejection based accounts, both (5b) and (6b) should be processed by first representing the positive argument (the competitor), and then representing the negation-consistent state of affairs (the target), thus predicting a delay in (5b) relative to (5a), and similarly in (6b) relative to (6a). However, the dynamic pragmatic account predicts that participants will represent the positive argument (the competitor) for (5b) but not (6b), as (5b) has a positive QUD and (6b) has a negative QUD. Thus we predict a delay in (5b) relative to (5a), but reduced or no delay in (6b) relative to (6a).

To measure the visual bias, we calculated natural log ratio of percentage of looks to target over competitor: $\mathrm{Ln}(P_{target}/P_{competitor})$. "Ln" refers to natural log, P_{target} refers to the percentage of looks to the target, and $P_{competitor}$ refers to the percentage of looks to the competitor. When the log ratio is 0, there is equal percentage of looks to target and competitor. When the log ratio is above 0, there is a bias towards the target, and when below 0, there is a bias towards the competitor. Figures 1 and 2 plot the log ratios for simple and cleft sentence, from the main verb to noun. As sentences differ in their onsets and offsets of words, the curves in Figs. 1 and 2 are resynchronized at the onset of each word, so that the graph more accurately reflects the evolving visual biases relative to the audio stimuli (Altmann and Kamide 2009).

For simple sentences (Fig. 1), there is a difference in log ratios between positive and negative from the offset of verb to the offset of noun. For positives, a bias towards target was formed immediately after the verb. For negatives, however, there are roughly equal amounts of looks to the target and the competitor after the verb, in the post-verb silence and "his" regions. A target bias was developed later. A region by polarity ANOVA shows that there is no region by polarity interaction, but instead a significant main effect of polarity (see Tian et al. under review for detailed tests results). This suggests that looks to the target versus the competitor is consistently different between positive and negative from the offset of the verb to the end of the sentence. Paired sampled t-tests show that the simple positive and negative conditions are significantly different in the post-verb silence + "his" region, "someone's" region and noun region. Time course analysis shows that a significant target bias is established 100 ms post-verb for simple positives, and 900 ms post-verb for simple negative.

For cleft sentences (Fig. 2), there is no difference between positives and negatives shortly after the verb. We can see that for both positive and negative sentences,

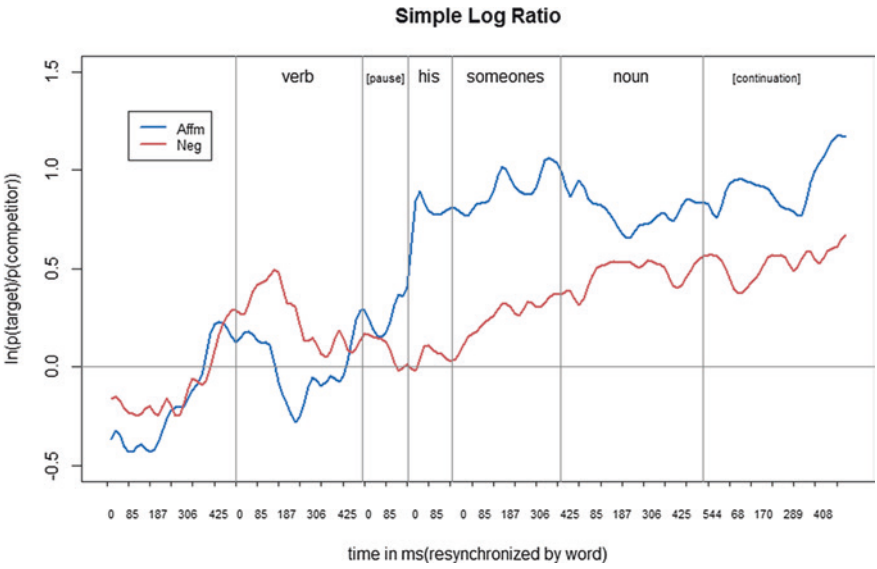

Fig. 1 Log ratio of percentage of looks to target over competitor for positive and negative conditions—simple

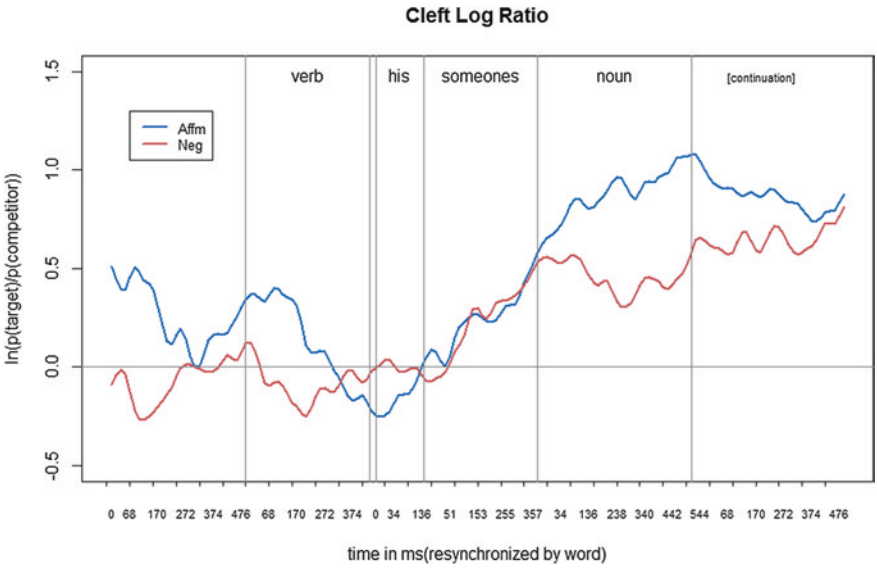

Fig. 2 Log ratio of percentage of looks to target over competitor for positive and negative conditions—cleft

participants pay comparable attention to target and competitor immediately after the verb. Bias to target develops after the offset of "his". A region by polarity ANOVA shows that there is no significant region by polarity interaction. Crucially, unlike the simple condition, here polarity does not have a significant main effect. Paired sampled t-tests on log ratios show that there is no difference between cleft positive and negative in post-verb silence + "his" region and "someone's" region, and only a trending difference in the "noun" region. Time course analysis shows that a significant target bias is established 500 ms post verb for cleft positives, and 600 ms post verb for simple negative. Combining the results of simple and cleft sentences, we performed a cleftness (2) × polarity (2) ANOVA on log ratios in a fixed length window starting from the offset of the verb, and found a significant interaction.

Our results show that for simple sentences, the processing of the simple negatives is delayed compared to the simple positives. However, the processing of cleft negatives and positive negatives have similar timecourses. Sentences of both polarities experienced some delay, and this is likely due to the complexity of the cleft construction. These results are incompatible with rejection based accounts. Rather, it is likely due to QUD accommodation, as predicted by the dynamic pragmatic account. One results suggest that QUD accommodation happens incrementally, soon after a cue (in this case negation) is encountered. However, this is not a distinctive first step that happens before the processing of sentence meaning. In the simple negative condition, participants paid comparable attention to both the representation of the positive argument and the negation consistent representation before shifting their attention away from the former. Our results also suggest that the meaning of negation can be incorporated incrementally. For cleft negatives, a target bias was formed 600 ms post verb, well before the onset of the noun.

6 Conclusions

Negative sentences are reported to be more difficult to process than positives, and their positive arguments are often represented in the early stage of processing. We propose the dynamic pragmatic account of negation processing: Negation is a cue for retrieving a prominent QUD. Without contextual support or further cues, the most prominent QUD for a negative sentence $\neg p$ is the positive question *whether p*. This process is automatic and incremental. As seen in corpus data, negation triggered QUD accommodation is very common in the case of implicit denial.

We propose that negation triggered QUD accommodation contributes to the difficulty of negative sentence processing, as the representation of the positive counterpart is incongruent to the representation of sentence consistent state of affairs. This idea challenges the rejection-based accounts, which propose that to process a negative sentence, we must first represent the positive. In three experiments, we have seen that representing the positive is not a mandatory first step. Rather it is likely due to QUD accommodation. When other cues in the sentence (such as a cleft construction) project a prominent negative QUD, we no longer represent the positive

when processing negation. More broadly, our findings support the idea that pragmatic information is incrementally updated during sentence processing, and that there is no pragmatics-free comprehension. We interpret utterances *in media res*. Sentences may appear to be independent entities when we read them in an experiment or hear them "out-of-the-blue". However, for a comprehender, they are always utterances produced by a speaker and situated in a broader discourse context.

References

Altmann, G., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition, 73*(3), 247–264.

Altmann, G., & Kamide, Y. (2007). The real-time mediation of visual attention by language and world knowledge: Linking anticipatory (and other) eye movements to linguistic processing. *Journal of Memory and Language, 57*(4), 502–518.

Altmann, G., & Kamide, Y. (2009). Discourse-mediation of the mapping between language and the visual world: Eye movements and mental representation. *Cognition, 111*(1), 55–71.

Arroyo, F. (1982). Negatives in context. *Journal of Verbal Learning and Verbal Behavior, 21*(1), 118–126.

Barr, D. J. (2008). Pragmatic expectations and linguistic evidence: Listeners anticipate but do not integrate common ground. *Cognition, 109*(1), 18–40.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*(04), 577–660.

Breheny, R., Ferguson, H. J., & Katsos, N. (2013). Taking the epistemic step: Toward a model of on-line access to conversational implicatures. *Cognition, 126*(3), 423–440.

Brown-Schmidt, S., Gunlogson, C., & Tanenhaus, M. (2008). Addressees distinguish shared from private information when interpreting questions during interactive conversation. *Cognition, 107*(3), 1122–1134.

Carlson, L. (1983). *Dialogue games: An approach to discourse analysis*. Dordrecht: Reidel.

Carpenter, P. A., & Just, M. A. (1975). Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review, 82*(1), 45–73.

Clark, H. H. (1976). *Semantics and comprehension*. The Hague: Mouton.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology, 3*(3), 472–517.

Cooper, R. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology, 6*, 84–107.

Cornish, E., & Wason, P. (1970). The recall of affirmative and negative sentences in an incidental learning task. *Quarterly Journal of Experimental Psychology, 22*(2), 109–114.

Dale, R., & Duran, N. D. (2011). The cognitive dynamics of negated sentence verification. *Cognitive Science, 35*(5), 983–996.

Evans, J. S. B. T., Clibbens, J., & Rood, B. (1996). The role of implicit and explicit negation in conditional reasoning bias. *Journal of Memory and Language, 35*(3), 392–409.

Fischler, I., Bloom, P. A., Childers, D. G., Roucos, S. E., & Perry, N. W. (1983). Brain potentials related to stages of sentence verification. *Psychophysiology, 20*(4), 400–409.

Ginzburg, J. (2012). *The interactive stance: Meaning for conversation*. Oxford: Oxford University Press.

Giora, R. (2006). Anything negatives can do affirmatives can do just as well, except for some metaphors. *Journal of Pragmatics, 38*(7), 981–1014.

Giora, R. (2016, this volume). When negatives are easier to understand than affirmatives: The case of negative sarcasm. In P. Larrivée & C. Lee (Eds.), *Negation and polarity: Experimental perspectives* (pp. 127–143). Cham: Springer.

Glenberg, A. M. (1997). What memory is for: Creating meaning in the service of action. *Behavioral and Brain Sciences, 20*(1), 41–50.

Glenberg, A. M., Robertson, D. A., Jansen, J. L., & Johnson-Glenberg, M. C. (1999). Not propositions. *Cognitive Systems Research, 1*(1), 19–33.

Gough, P. (1965). Grammatical transformations and speed of understanding. *Journal of Verbal Learning and Verbal Behavior, 4*(2), 107–111.

Grice, H. (1975). Logic and conversation. In R. Stainton (Ed.), *Perspectives in the philosophy of language* (pp. 41–58). Cambridge: Harvard University Press.

Hasson, U., & Glucksberg, S. (2006). Does understanding negation entail affirmation? An examination of negated metaphors. *Journal of Pragmatics, 38*(7), 1015–1032.

Hedberg, N., & Sosa, J. (2003). *Pitch contours in negative sentences*. Poster presented at the 15th International Congress of Phonetic Sciences, Barcelona.

Hindy, N. C., Solomon, S. H., Altmann, G. T. M., & Thompson-Schill, S. L. (2013). A cortical network for the encoding of object change. *Cerebral Cortex*, bht275.

Horn, L. R. (1978). Lexical incorporation, implicature, and the least effort hypothesis. *CLS*, *14*, 196–209.

Huettig, F., Rommers, J., & Meyer, A. S. (2011). Using the visual world paradigm to study language processing: A review and critical evaluation. *Acta Psychologica, 137*(2), 151–171.

Karttunen, L. (1974). Presupposition and linguistic context. *Theoretical Linguistics, 1*(1), 181–194.

Kaup, B., Yaxley, R. H., Madden, C. J., Zwaan, R., & Lüdtke, J. (2007a). Experiential simulations of negated text information. *Quarterly Journal of Experimental Psychology, 60*, 976–990.

Kaup, B., Zwaan, R., & Lüdtke, J. (2005). Effects of negation, truth value, and delay on picture recognition after reading affirmative and negative sentences. In B. G. Bara et al. (Eds.), *Proceedings of the 27th Annual Conference of the Cognitive Science Society* (pp. 1114–1119). Mahwah: Erlbaum.

Kaup, B., Zwaan, R., & Lüdtke, J. (2006). Procesing negated sentences with contradictory predicates: Is a door that is not open mentally closed? *Journal of Pragmatics, 38*, 1033–1050.

Kaup, B., Zwaan, R., & Lüdtke, J. (2007b). The experiential view of language comprehension: How is negated text information represented? In F. Schmalhofer & C. A. Perfetti (Eds.), *Higher level language processes in the brain: Inference and comprehension processes* (pp. 255–288). Mahwah: Erlbaum.

Lee, C. (2016, this volume). Metalinguistically negated versus descriptively negated adverbials: ERP and other evidence. In P. Larrivée & C. Lee (Eds.), *Negation and polarity: Experimental perspectives* (pp. 229–255). Cham: Springer.

Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.

Lewis, D. (1979). Scorekeeping in a language game. *Journal of Philosophical Logic, 8*(1), 339–359.

Lüdtke, J., Friedrich, C. K., De Filippis, M., & Kaup, B. (2008). Event-related potential correlates of negation in a sentence-picture verification paradigm. *Journal of Cognitive Neuroscience, 20*(8), 1355–1370.

Lüdtke, J., & Kaup, B. (2006). Context effects when reading negative and affirmative sentences. In R. Sun & N. Miyake (Eds.), *Proceedings of the 28th Annual Conference of the Cognitive Science Society* (pp. 1735–1740). Mahwah: Erlbaum.

Mckinstry, C., Dale, R., & Spivey, M. J. (2008). Action dynamics reveal parallel competition in decision making. *Psychological Science, 19*(1), 22–24.

Nieuwland, M. S., & Kuperberg, G. R. (2008). When the truth is not too hard to handle: an event-related potential study on the pragmatics of negation. *Psychological Science: A Journal of the American Psychological Society/APS, 19*(12), 1213–1218.

Oaksford, M., & Stenning, K. (1992). Reasoning with conditionals containing negated constituents. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 18*(4), 835.

Prado, J., & Noveck, I. A. (2006). How reaction time measures elucidate the matching bias and the way negations are processed. *Thinking & Reasoning, 12*(3), 309–328.

Roberts, C. (2012). Information structure in discourse: Towards an integrated formal theory of pragmatics. *Semantics and Pragmatics, 5*(6), 1–69.
Russell, B. (1948). *Human knowledge: Its scope and limits*. New York: Simon & Schuster.
Stalnaker, R. (1973). Presuppositions. *Journal of Philosophical Logic, 2*, 447–457.
Stalnaker, R. (1978). Assertion. In P. Cole (Ed.), *Syntax and semantics* (pp. 315–332). New York: Academic Press.
Stalnaker, R. (1998). On the representation of context. *Journal of Logic, Language and Information, 7*, 3–19.
Tanenhaus, M. K., Carroll, J., & Bever, T. (1976). Sentence-picture verification models as theories of sentence comprehension: A critique of Carpenter and Just. *Psychological Review, 83*(4), 310–317.
Tanenhaus, M. K., Spivey-Knowlton, M., Eberhard, K., & Sedivy, J. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*(5217), 1632–1634.
Tettamanti, M., Manenti, R., Della Rosa, P. A., Falini, A., Perani, D., Cappa, S. F., & Moro, A. (2008). Negation in the brain: Modulating action representations. *Neuroimage, 43*(2), 358–367.
Tian, Y. (2014). *Negation processing: A dynamic pragmatic account*. Ph.D. dissertation, University College London.
Tian, Y., & Breheny, R. (Under review). A new look at negative sentence verification.
Tian, Y., Breheny, R., & Ferguson, H. (2010). Why we simulate negated information: A dynamic pragmatic account. *Quarterly Journal of Experimental Psychology, 63*(12), 2305–2312.
Tian, Y., Ferguson, H., & Breheny, R. (Under review). Processing negation without context—Why and when we represent the positive counterpart.
Tomasino, B., Weiss, P. H., & Fink, G. R. (2010). To move or not to move: imperatives modulate action-related verb processing in the motor system. *Neuroscience, 169*(1), 246–258.
Tottie, G. (1991). *Negation in English speech and writing: A study in variation*. San Diego: Academic Press.
Trabasso, T., & Rollins, H. (1971). Storage and verification stages in processing concepts. *Cognitive Psychology, 2*(3), 239–289.
Van Berkum, J., van den Brink, D., Tesink, C. M. J. Y., Kos, M., & Hagoort, P. (2008). The neural integration of speaker and message. *Journal of Cognitive Neuroscience, 20*(4), 580–591.
Van der Sandt, R. (1988). *Context and presupposition*. London: Croom Helm.
von Fintel, K. (2004). Would you believe it? The king of France is back! Presuppositions and truth-value intuitions. In M. Reimer & A. Bezuidenhout (Eds.), *Descriptions and beyond* (pp. 315–341). Oxford: Oxford University Press.
von Fintel, K. (2008). What is presupposition accommodation, again? *Philosophical Perspectives, 22*(1), 137–170.
Wales, R. J., & Grieve, R. (1969). What is so difficult about negation? *Perception and Psychophysics, 6*(6), 327–332.
Wallage, P. (2016, this volume). Identifying the role of pragmatic activation in the changes to the expression of English negation. In P. Larrivée & C. Lee (Eds.), *Negation and polarity: Experimental perspectives* (pp. 199–227). Cham: Springer.
Wason, P. (1961). Response to affirmative and negative binary statements. *British Journal of Psychology, 52*, 133–142.
Wason, P. (1965). The contexts of plausible denial. *Journal of Verbal Learning Verbal Behavior, 4*(1), 7–11.
Young, R., & Chase, W. G. (1971). Additive stages in the comparison of sentences and pictures. Paper presented at the *Midwestern Psychological Association meetings*, Chicago.
Zwaan, R. (2004). The immersed experiencer: Toward an embodied theory of language comprehension. *Psychology of Learning and Motivation*, *44*, 35–62.

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