

Chapter 10

What psycholinguistic negation research tells us about the nature of the working-memory representations utilized in language comprehension

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1. Introduction

It is a well known fact that in linguistic communication usually only very few aspects of the to be described state of affairs are indeed stated explicitly. In fact, this aspect of linguistic communication seems essential because otherwise it would hardly constitute an effective means for the exchange of information. From the perspective of the listener or reader this implies that he or she is expected to make certain assumptions concerning those aspects of the state of affairs at hand that seem relevant but were not described explicitly. These assumptions that the reader or listener usually makes on the basis of his or her general world knowledge, knowledge about the communicative partner, and knowledge about the communicative context, are called inferences. Obviously, the reader or listener will sometimes arrive at wrong inferences, i.e., infer information that does not hold for the state of affairs under consideration. This will typically occur when the respective state of affairs deviates in certain aspects from its prototypical exemplar. In cases such as these, the speaker, at least if he or she considers the respective mistake as important, needs to explicitly correct the wrongly made inferences. Typically, he or she will do so by means of a negated sentence. Thus, negation can be considered a highly important means of communication.

Whereas negation has been thoroughly studied in linguistics and philosophy (for an overview, see Horn 1989), psycholinguistic studies on the processing of negation are relatively rare. In Psycholinguistics, there was considerable interest in negation in the 1960s and 1970s. However, most of the studies conducted in these years concerned rather global aspects of negation, such as the particular difficulties that comprehenders encounter when processing a negated sentence. In subsequent years, negation nearly completely disappeared from the research topics in Psycholinguistics. Only recently and

only slowly has negation now reappeared in psycholinguistic research. One reason for this new interest in negation may have to do with the fact that in recent years new theoretical positions have emerged regarding the question of the exact nature of the working memory representations that are utilized in language comprehension. Whereas the classical view postulates that language comprehension involves propositional representations of the linguistic input, more and more authors nowadays lean towards the view that language comprehension is tantamount to mentally simulating the described state of affairs. According to this latter view, language comprehension involves non-linguistic representations of the described states of affairs that are similar in nature to the representations that are being constructed when directly experiencing the corresponding states of affairs. In the context of this debate, negation seems particularly relevant because the two different representational views differ clearly with respect to assumptions concerning the representations constructed for negated sentences. The present chapter will deal with the question of what psycholinguistic research on negation can tell us about the memory representations constructed in language comprehension. In the first section, I will give an overview on the different theoretical notions regarding the exact nature of the working memory representations utilized in language comprehension. In particular, I will focus on the assumptions regarding the question of how negation is processed and represented. In the second section, I will summarize the relevant findings of psycholinguistic studies concerned with the processing, representation or interpretation of negated sentences. The findings will be discussed in relation to the different theoretical notions that were introduced in the first section. In the third and final section I will draw conclusions with respect to the nature of the working memory representations created in language comprehension.

2. Representations utilized in comprehension: Theoretical notions

2.1. The classical view: Propositional theories of comprehension

According to propositional theories (e.g., Kintsch and van Dijk 1978; Kintsch 1988; McKoon and Ratcliff 1992), comprehending linguistic material means creating a propositional representation of it. The basic unit in a propositional representation is the proposition. In Psychology, a proposition corresponds to the representation of the meaning of an informational unit that is large

enough to carry a truth value. A proposition consists of a relation and one or more arguments. Take, for instance, sentence (1) which states that there is a person named Sam, a hat, and a particular relation holding between them, namely that of wearing. Sam is the agent, and accordingly, the propositional representation for (1) is as in Figure 1.

- (1) Sam is wearing a hat.

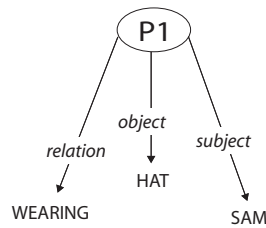


Figure 1. Propositional representation for sentence (1).

When constructing a propositional representation, the comprehender is assumed to monitor the linguistic input for coherence. A coherent propositional representation requires that each proposition can be attached to another proposition on the basis of argument overlap. In the representation for (2), for instance, propositions P1 and P2 share the argument 'SAM', P1 and P3 share 'HAT' and P2 and P4 share 'UMBRELLA' (see Figure 2). If a proposition comes up in the linguistic input that cannot be connected to any of the other propositions held available in working memory, background knowledge comes into play and may help to fill the gap by making available an inference that can be used as interlink. For instance, in the representation for sentence (3), propositions P1 and P2 can be connected by the inference P3 (see Figure 3; cf. Kintsch and van Dijk, 1978).

- (2) Sam is wearing a hat and carrying an umbrella. The hat is grey and the umbrella is red.
- (3) Sam enters the restaurant. The waiter is drunk.

The conditions under which (different types of) inferences are being drawn, the exact role that background knowledge plays in the comprehension process, as well as the time course of background knowledge involvement in the comprehension process has been a topic of much debate in the literature

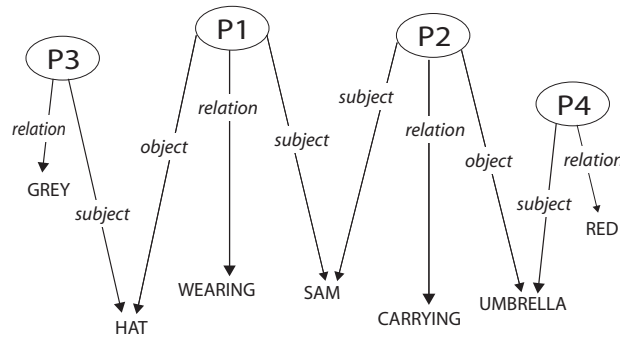


Figure 2. Propositional representation for (2).

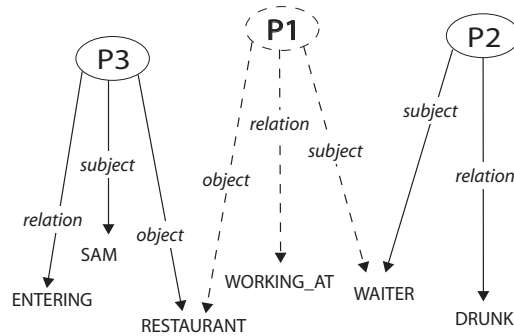


Figure 3. Propositional representation for (3).

(for an overview see Graesser, Singer, and Trabasso 1994). However, in the present chapter, I will not go into detail with respect to these questions, as they are not central for the present purpose. Instead, I will now turn to the question of how negation is represented in a propositional representation.

In a propositional representation, negation is considered an explicitly represented operator that takes a whole proposition into its scope, namely the proposition that is being negated. Take, for instance, sentence (4) which negates the proposition that Sam is wearing a hat. Accordingly, in the propositional representation for (4), this proposition appears as the argument of a higher-level proposition, the relation of which is the negation operator (see Figure 4). Thus, according to propositional theories of comprehension, con-

structuring the meaning representation for a negative sentence is necessarily more complex than constructing the meaning representations for the corresponding sentence without negation. The former generally involves one additional level of propositional encapsulation. Hence, negative sentences should be more difficult to process and comprehend than the corresponding affirmative sentences without negation.

(4) Sam is not wearing a hat.

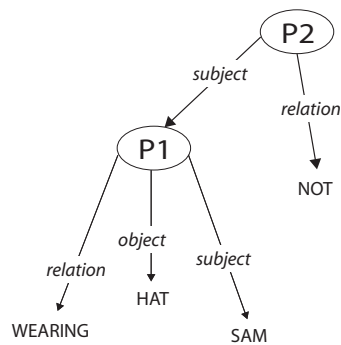


Figure 4. Propositional representation for (4).

It should be noted that this prediction is to be qualified when the pragmatics of negation is taken into account. It is well known that the contexts in which negative utterances occur are rather limited. Typically, negative statements are uttered when the negated proposition was either explicitly mentioned before by one of the discourse partners or at least constitutes a plausible assumption in the respective context. Thus, negation is used to communicate deviations from expectations (Givon 1978; Glenberg, Robertson, Jansen, and Johnson-Glenberg 1999; Wason 1965; see also, Arroyo 1982; Cornish 1971; Greene 1970; deVilliers and Tager-Flusberg 1975). Two cases need to be distinguished. The first case is where the negated text information is already represented in the representation that is available prior to encountering the negation, be it because it was explicitly mentioned by one of the discourse partners or because it was inferred by the comprehender on the basis of his or her general world knowledge. In this case, all the comprehender needs to do when processing the negation is to encapsulate the respective proposition into the negation operator. Accordingly, in this case negative sentences should be relatively easy to comprehend. Sentence (5) may serve as an example. The

noun phrase *a classical wedding* most likely gives rise to the inference that the bride was wearing a white dress. When processing the negation in the second clause, all the comprehender needs to do is encapsulate the inferred proposition into the negation operator.

The second case is where the negated information is not represented in the representation that is available when encountering the negation, be it because the negative sentence is presented out of context or because the respective expectation was not strong enough to trigger forward inferences of the required type. In this case, the comprehender needs to construct the complex negated proposition from scratch, and comprehension times should accordingly be relatively long. Text (6) may serve as an example. It seems unlikely that the first sentence gives rise to the inference that Jim brought a snorkel and goggles. When encountering the negation, the reader needs to create a propositional representation of the negated proposition (Jim brought snorkel and goggles) and place this in the scope of the negation operator. Thus in this case it can be expected that negative sentences are relatively hard to process.

- (5) Overall it was a classical wedding, but the bride's dress was not white.
- (6) Overall Jim was very well prepared for his day at the beach. However, in the afternoon he realized that he had not brought his snorkel and goggles.

More interesting than these rather global predictions concerning processing difficulty are predictions that can be derived regarding the availability of text information. Advocates of propositional theories of language comprehension assume that concepts that are represented in a negated proposition are less available after reading than concepts represented in affirmative propositions, simply by being encapsulated by the negation operator (MacDonald and Just 1989). Thus, according to propositional theories of comprehension, the concept HAT should be less available after reading (4) than after reading (1).

2.2. Situation-model theory / Discourse-representation theory

According to situation-model theory (e.g., van Dijk and Kintsch 1983; Morrow, Bower, and Greenspan 1990; Zwaan and Radvansky 1998), the basic unit of the meaning representations created in language comprehension are not propositions, but mental tokens representing the referents that the linguistic input introduces and refers to. Thus, it is assumed that language comprehen-

sion consists of creating a referential representation of the linguistic input. In contrast to a propositional representation, which can be considered a description of a state of affairs in a mental language, a referential representation is a representation of the state of affairs itself (cf. Glenberg, Meyer, and Lindem 1987; Johnson-Laird 1983; Morrow et al. 1990; van Dijk and Kintsch 1983; Zwaan and Radvansky 1998). Not all proponents of situation-model theory are very explicit about the representational format of the representation. However, usually it is implicitly assumed that the referential level of representation, which consists of mental tokens representing the relevant referents, is augmented by propositions that assign properties and relations to these tokens. Thus, in this respect situation-model theory resembles the linguistic discourse representation theory (DRT, Kamp 1981). As DRT is very specific in its (representational) assumptions, and moreover explicitly deals with negation, I will use the well-known DRT format of representational visualization in what follows. Let us return to sentence (1). This sentence refers to two discourse referents, namely Sam and a hat. Thus, the referential level of representation contains two tokens x and y . Furthermore, the sentence specifies properties of and relations among these entities. x is specified as being named *Sam*, and y as being a hat. The relation holding between the two discourse referents is that of wearing. Accordingly, the discourse representation structure (DRS) created for (1) is as in Figure 5A.

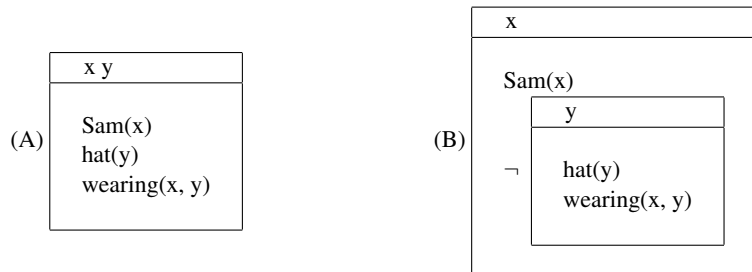


Figure 5. DRT representations for sentences (1) and (4) respectively.

In DRT, negation is a linguistic operator that is applied to a subordinate DRS. This subordinate DRS represents that part of the semantic representation of the sentence that is in the scope of the negation operator. Accordingly, the representation for (4) is as in Figure 5B. As with propositional theories of comprehension, one therefore arrives at the prediction that negative sen-

tences are more complex to comprehend than the corresponding affirmative sentences, except when the negative sentences are presented in a pragmatically felicitous context, in which the negated proposition was represented prior to encountering the negation (see above).

DRT also allows predictions with respect to the availability of information mentioned in negative sentences: Discourse referents that are represented in a subordinate DRS are assumed to be unavailable for anaphor resolution in the main DRS¹. The rationale for this assumption is that discourse referents represented in the main DRS correspond to entities in the described world, whereas discourse referents represented in a sub-DRS (usually) do not. Thus, with respect to the availability of the concept HAT, DRT arrives at the same predictions as propositional theories of comprehension: The concept HAT should be more available after reading (1) than after reading (4). However, DRT differs from propositional theories with respect to assumptions concerning the availability of discourse referents that are only referred to but not introduced within the scope of the negation operator. An example is Sam in (4). In a propositional representation, Sam is part of a negated proposition and should therefore be relatively inaccessible. In the DRT representation however, Sam is represented in the accessible main DRS. According to DRT, the availability of Sam should therefore not be reduced after (4) compared to (1).

To summarize, DRT predicts that discourse referents introduced in the scope of the negation operator are less available than discourse referents that were introduced in affirmative phrases. Discourse referents that are not *introduced* but only *referred to* in a negative proposition, however, are not less available than referents mentioned in affirmative propositions.

2.3. The experiential-simulations view of comprehension

Recently, the notion that situation models created in language comprehension are of a representational format that is the same as that utilized in other non-linguistic cognitive processes (e.g., perception, action, imagery) has been gaining in importance in text comprehension research (e.g., Barsalou 1999; Glenberg 1997; Glenberg and Kaschak 2002; Glenberg and Robertson 1999; Kelter 2003; Kelter, Kaup, and Claus 2004; MacWhinney 1999; Stanfield and Zwaan 2001; Zwaan 2004; Zwaan, Stanfield, and Yaxley 2002, see also Johnson-Laird 1983). Proponents of this notion believe that comprehenders

construct mental simulations of the states of affairs described in the text. These mental simulations are considered to be experiential in nature as they are assumed to be grounded in perception and action. There is already some empirical evidence for the experiential view of language comprehension. On the one hand there are neuroscience studies that directly show a considerable overlap between the mental subsystems in which linguistically conveyed situational information is represented and those that are involved when these situations are directly perceived or en-acted (e.g., Pulvermüller 2002; Pulvermüller, Haerle, and Hummel 2001). On the other hand, there is behavioral data that suggest that language comprehension leads to the creation of representations in those mental subsystems that are utilized in other non-linguistic cognitive processes such as action planning, perception or imagery (for an overview, see Zwaan 2004). The question of how negation is represented in these experiential simulations is interesting, considering that negation is a linguistic operator that cannot be assumed to be represented explicitly in these non-linguistic mental simulations. Instead it must be assumed that negation is implicitly encoded. One hypothesis regarding the implicit representation of negation is the *two-step-simulation hypothesis* (Kaup, Zwaan, and Lüdtke in press): The processing of negation involves two simulations, a simulation of the negated state of affairs and a simulation of the actual state of affairs. The simulation of the negated state of affairs is kept separate from the simulation of the actual state of affairs, and it is assumed that during and shortly after the processing of the negation, the comprehender routinely focusses attention on the simulation of the negated state of affairs, whereas at a later point in time in the comprehension process, the comprehender shifts attention (back) towards the actual state of affairs. The negation is then captured in the deviations between the two simulations (Kaup and Zwaan 2003; Kaup et al. in press).

For illustrative purposes let us again return to sentences (1) and (4) here repeated as (7) and (8).

- (7) Sam is wearing a hat.
- (8) Sam is not wearing a hat.

In the state of affairs described in (7) Sam is wearing a hat. Accordingly, a comprehender would simulate Sam with a hat (see Figure 6A). In the state of affairs described in (8), Sam is not wearing a hat. Accordingly, the comprehender simulates Sam without a hat (actual state of affairs). However, in

order to understand what it is that is being negated, the comprehender also simulates the negated state of affairs, namely Sam with a hat. This simulation is not integrated with the simulation of the actual state of affairs, but rather is kept separate in an auxiliary representational system. A comparison of the two simulations then allows reconstructing the negated text information. In other words, the comprehender can reconstruct that it was a hat that Sam was not wearing, instead of, for instance, glasses (see Figure 6B).

Thus, the experiential-simulations view arrives at similar predictions as the two other representational views with respect to processing difficulties. Negative sentences that are presented in isolation should take longer to comprehend than the corresponding affirmative sentences without negation, because in the negative case two simulations need to be created. In pragmatically felicitous contexts, however, the comprehender already has available a simulation of the negated state of affairs when encountering the negation, because the negated proposition was either explicitly mentioned by one of the discourse partners or was inferred on the basis of the comprehender's general world knowledge. In this case, all the comprehender needs to do is create a simulation of the actual state of affairs, and accordingly there is no reason to expect that negative sentences in this case are harder to understand than the corresponding affirmative sentences without negation.

With respect to the predictions concerning the availability of the concept HAT, the experiential-simulations view also arrives at a similar prediction as the two other theoretical accounts: From a certain point in the comprehension process on, comprehenders shift their attention from the simulation of the negated state of affairs (Sam with a hat) to the simulation of the actual state of affairs (Sam without a hat). Accordingly, from certain point in the comprehension process on HAT should be less available after reading (8) than after reading (7).

The experiential-simulations view of language comprehension agrees with DRT concerning the availability of SAM. Sam is present in both, the simulation of the negated as well as the simulation of the actual state of affairs. Thus, in contrast to what was predicted by propositional theories, the experiential-simulations view predicts that SAM should not be less accessible after reading (8) than after reading (7). It should be noted that although the experiential-simulations view and DRT arrive at the same predictions in this case, they do so for slightly different reasons. According to DRT, the reason why negation does not affect the availability in this case is that the respective discourse referent represents an entity in the discourse world and is therefore not rep-

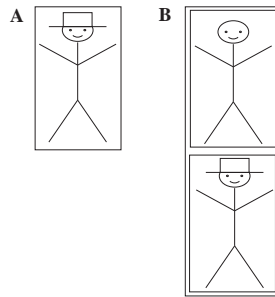


Figure 6. Experiential simulation for sentences (7) and (8), respectively.

resented in the negated sub-DRS. According to the experiential-simulations view, in contrast, the reason is that the respective entity is not *absent* from the resulting state of affairs and is therefore not absent from the simulation that is available at the end of the comprehension process. Hence, different predictions emerge in case the version with an explicit negation differs from the version without an explicit negation with respect to the absence/presence of the target entity in the resulting state of affairs. For instance, in (9) and (10), the discourse referent representing a hat corresponds to an entity in the described world in both cases. Thus, according to DRT availability of HAT should not differ between the two versions of the sentence. However, the two versions *do* differ with respect to the hat's presence in the resulting state of affairs. In the version with an explicit negation [i.e., (10)] the hat is present, whereas in the version without an explicit negation [i.e., (9)], it is absent from the resulting situation. Accordingly, in contrast to the predictions of DRT, the experiential-simulations view in this case predicts better (!) availability in the version with an explicit negation than in the version without an explicit negation.

(9) Sam forgot to wear his hat.

(10) Sam did not forget to wear his hat.

To summarize, according to the experiential view of language comprehension, availability should not depend on the linguistic form in which the respective entities were being introduced into the discourse. Rather, availability should mainly depend on the content of the described state of affairs. From a certain point in the comprehension process on, entities that are present in the described state of affairs should be better available than entities absent

from the described state of affairs independent of the polarity (affirmative or negative) of the introducing phrase. Polarity effects should if at all show up early in the comprehension process when comprehenders are still engaged in creating the simulations of the described state of affairs.

3. Relevant findings

3.1. Negation and processing difficulty

A considerable amount of research into the processing of negation was conducted in the 1960's and 1970's. In numerous studies employing a variety of different methods and materials participants were presented with sentences or sentence fragments that either did or did not contain negative particles. Most of these studies employed sentence-verification tasks in which the sentences were to be verified either against background knowledge (e.g., Arroyo 1982; Eiferman 1961; Wales and Grieve 1969; Wason 1961; Wason and Jones 1963), or against a picture that was presented before or after the corresponding sentence (e.g., Carpenter and Just 1975; Clark and Chase 1972; Gough 1965, 1966; Just and Carpenter 1971; Trabasso, Rollins, and Shaughnessy 1971). Other studies employed sentence-completion tasks (e.g., Donaldson 1970; de Villiers and Flusberg 1975; Wason 1959; Wason 1961, 1965). Yet other studies investigated the impact of negation more indirectly, for instance by measuring the number of inferences that were drawn from negative sentences compared to the number of inferences drawn from affirmative sentences (e.g., Just and Clark 1973), by measuring how well negative instructions are followed (e.g., Jones 1966, 1968) or by investigating the impact of a negative object description in object-selection tasks (Donaldson 1970).

In all of these studies, negative sentences were harder to process than affirmative sentences, as is evidenced by longer processing times and/or higher error rates for negative sentences compared to affirmative sentences. Various explanations have been proposed to account for the difference in processing difficulty between affirmative and negative sentences. An obvious explanation is that negative sentences necessarily contain an extra syllable compared to the corresponding affirmative sentences. However, the reading time differences that are due to this extra syllable can at best account for a small part of the processing differences between affirmative and negative sentences (for details see Clark and Chase 1972). Other explanations were based on

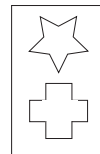
Chomsky's transformational grammar, or on connotational and pragmatic aspects of negation (e.g., Wason 1961). Instead of going into detail with respect to these explanatory attempts (see Kaup et al. in press for a comprehensive overview), I will briefly discuss the findings in the context of the three representational views outlined in the previous section. All three accounts have a natural way of accounting for the general processing difficulty associated with negative sentences. In a propositional representation, the representation constructed for a negative sentence not only contains an extra proposition but also an extra level of propositional encapsulation compared to the representation for the corresponding affirmative sentence. Thus, it is not surprising that negative sentences are more difficult to process than the corresponding affirmative sentences without negation. The same holds for the discourse representations in DRT. The DRS for a negative sentence contains the negation operator plus an extra subordinate DRS. In the experiential-simulations view, negative sentences are assumed to trigger additional simulations compared to the corresponding affirmative sentences without negation. Thus, according to all accounts, negative sentences are associated with more complex representations than the corresponding sentences without negation. The more complex a representation gets the more processing time is required to construct the representation and the more difficult and error-prone are processes that operate on the representations. Hence, all three accounts can explain, and do even predict, an impact of negation on the processing difficulty of linguistic material.

As was discussed in the previous section, all three accounts also predict that the differences in processing difficulty between affirmative and negative sentences should be diminished in case the sentences are presented in a pragmatically felicitous context, in which the negated proposition was either explicitly mentioned before or at least constitutes a highly plausible assumption. The results of a couple of studies are in line with this prediction. For instance, in a study by Wason (1965) participants were presented with pictures of eight circles, seven in one color and one in another color. They were then asked to complete affirmative or negative sentence fragments. Negative fragments (e.g., *Circle No 3 is not ...*) took longer to complete than affirmative fragments (e.g., *Circle No 3 is ...*), but this difference was significantly smaller when the negative sentences referred to the circle with the exceptional color than when they referred to one of the seven other circles (see also Cornish 1971; de Villiers and Tager-Flusberg 1975; Glenberg et al. 1999).

3.2. Negation and the impact of truth value

As mentioned earlier, most of the discussed studies employed a sentence-verification task. Thus, these studies provided information not only with respect to the affirmation/negation manipulation, but also with respect to the truth value of the sentence that was being verified. Although very stable results were obtained with respect to the impact of the negation operator, the various studies do not allow definite conclusions about the impact of the sentence's truth value. In some studies, false sentences were generally harder to process than true sentences, independent of whether or not they contained a negation operator (Arroyo 1982; Eiferman 1961; Gough 1965; Trabasso et al. 1971; see also Wason 1959, 1961). The majority of the studies, however, have produced a negation-by-truth-value interaction. Whereas true affirmative sentences [e.g., (11)] are easier to evaluate than false affirmative sentences [e.g., (12)], the opposite holds for negative sentences; here, true sentences [e.g., (13)] are more difficult to process than false ones [e.g., (14)].

- (11) The star is above the plus.
- (12) The plus is above the star.
- (13) The star is not above the plus.
- (14) The plus is not above the star.



To account for the two patterns of verification latencies, it was suggested that comprehenders encode the pictures, just as the sentences, in a propositional format. Both representations are then compared constituent by constituent, with the comparison process being easier when the two constituents are congruent than when they are incongruent (for a detailed description of the model, see Carpenter and Just 1975; Clark and Chase 1972). Two strategies can be distinguished that produce the two observed response-time patterns (main effect of truth value vs. negation-by-truth-value interaction). The negation-by-truth-value interaction arises when participants are using the original sentence representation for the comparison process. For true affirmative sentences [e.g., (11)], the order of the arguments in the sentence representation matches the order of the arguments in the picture representation [both: above (star, plus)], whereas for false affirmatives [e.g., (12)] there is a mismatch with respect to the order of the arguments [sentence: above (plus, star); picture: above (star, plus)]. This explains why false affirmatives take longer to verify than true affirmatives. In contrast, for negatives, it is the false case

in which there is a match [e.g., (13); sentence: not(above(star,plus)); picture: above(star,plus)], and the true case where there is a mismatch [e.g., (14); sentence: not(above(plus, star)); picture: above(star, plus)]. This explains why true negatives take longer to verify than false negatives. Thus, the negation-by-truth-value interaction can be accounted for by these assumptions. The main effect of negation is explained similarly. For negative sentences, the sentence representation contains a negation marker that mismatches with the affirmative picture representation. Accordingly, negative sentences take longer to verify than affirmative sentences.

The strategy producing a main effect of truth value differs from the preceding strategy in that participants convert the negative sentence into an affirmative one with the same truth conditions before starting the comparison process [e.g., (14) is converted into (11), and (13) into (12)]. After this conversion, true sentences imply a match and false sentence imply a mismatch, which explains the main effect of truth value. The main effect of negation is attributed to the fact that converting a negative sentence into an affirmative sentence takes time.

Let us now turn to the question of what the results concerning the impact of the truth value tell us about the nature of the working memory representations utilized in language comprehension. As should have become evident, the original explanations put forward by the studies' authors themselves were based on propositional theories of comprehension. The explanations presupposed that linguistic material is routinely represented in propositional representations in comprehension and subsequent verification. Thus, propositional theories of comprehension can account for the reported findings. The findings are also in line with DRT. As was outlined before, DRT differs from propositional theories mainly with respect to the assumption concerning the referential level of representation. The attributive component of DRT, however, completely complies with propositional theories of comprehension. The materials employed in the reported sentence-verification studies were such that discourse referents were not introduced but merely referred to in the scope of the negation operator. Hence, the affirmative and negative versions of the materials do not differ with respect to whether or not the relevant discourse referents are represented in the accessible main DRS. Accordingly, the referential level of representation should not play a central role in the explanation of the results. As a consequence, DRT can in principle offer the exact same explanatory account for the findings as propositional theories of comprehension do.

Do the findings then pose problems for the experiential- simulations view of comprehension? The answer is no. As was outlined above, negation is assumed to involve two simulations, a simulation of the negated state of affairs and a simulation of the actual state of affairs. Thus, in principle both simulations can be expected to affect the ease with which a particular picture can be processed after reading or listening to the sentences in a sentence-picture verification task. More specifically, a negation-by-truth-value interaction comes about when response times are faster for false negatives than they are for true negatives. In other words, responses are fast when the picture matches the *negated* state of affairs. From the perspective of the experiential-simulations view of comprehension, this response time pattern should be observed at a point in time at which the comprehender can be expected to still be focussing his or her attention on the *negated* state of affairs. In contrast, a main effect of truth value is observed when true negatives lead to shorter response times than false ones. In other words, response times are short when the picture matches the *actual* state of affairs. This response time pattern should therefore be observed at a point in time at which the comprehender can be expected to have shifted his or her attention towards the *actual* state of affairs.

Thus, this explanation of the results differs from the classical accounts mainly in two respects: First, instead of assuming that differences in response time reflect differences in the ease with which the representation of the picture can be compared to the representation of the sentence, it is assumed that they reflect differences in the degree to which the processing of the picture is primed by the simulation processes that have been carried out when comprehending the sentence. Second, instead of attributing the two different response time patterns (interaction vs. main effect) to different processing strategies, these response time patterns are related to different stages of one and the same processing mechanism.

The interesting question is whether the conditions under which one or the other match effect is observed correspond to the predictions of the experiential-simulations view. Directly in line with this view is the observation that a main effect of truth value is observed when there is a delay between the end of the sentence and the presentation of the second source of information (cf. Carpenter and Just 1975: 66; for evidence with a sentence-sentence verification task, see Carpenter 1973). With no delay, comprehenders are likely still focussing on the negated state of affairs. From a certain delay on, however, they have presumably shifted their attention the actual situation. As a consequence, responses after a certain delay depend on the match or mismatch

with the actual situation not with the negated situation. Similarly, that extensive practice (e.g., Carpenter and Just 1975) and high spatial ability (e.g., MacLeod, Hunt, and Mathews 1978) lead to a main effect of truth value suggests that practiced and high-spatial ability comprehenders arrive at the second stage at an earlier point in time than other comprehenders, which should enhance the probability of a match effect with respect to the actual situation. Finally, the experiential-simulations view explains why a main effect of truth value has mainly been found in experiments using two complementary predicates or the same contrary predicates throughout (e.g., Trabasso et al. 1971, see also Mayo, Schul, and Burnstein 2004). In these conditions it seems particularly likely that comprehenders shift their attention towards the actual situation, as the negative sentence allows deducing properties of this state of affairs (The door is not closed \rightarrow the door is open).

The experiential-simulations account of the respective empirical phenomena predicts that the results obtained with sentence-verification tasks should generalize to experimental tasks that do not require verification. According to the experiential-simulations view, the processing of sentences routinely leads to mental simulations of the described states of affairs. These simulations in turn potentially affect responses to subsequently presented pictures. Picture identification is assumed to be facilitated when the picture matches the experiential simulation that comprehenders have available from processing the sentence, independent of whether or not the pictures are verified against the sentences. A recent study conducted in collaboration with Jana Lüdtkke and Rolf A. Zwaan correspond to these predictions (Kaup, Lüdtkke, and Zwaan 2005).

In this study, participants were presented with sentences of the form *The X is (not) above/below the Y* followed by pictures of two objects, one above the other. The participants' task was to decide as quickly as possible whether both of the depicted objects had been mentioned in the sentence or not. In experimental trials, the correct response was always 'yes', but in half of the trials the picture matched the situation described by the sentence (true) whereas in the other half of the trials the picture mismatched this situation (false). For negated sentences, the picture in the latter condition matched the negated situation. For instance, for *The lion is above the dolphin* the picture in the true condition would depict a lion above a dolphin (see Figure 7A), whereas in the false condition it would depict a dolphin above a lion (see Figure 7B). For *The lion is not above the dolphin*, the picture in the true condition would depict a dolphin above a lion (see Figure 7B), whereas in the false condition, it

would depict a lion above a dolphin (see Figure 7A). In addition to the polarity of the sentence (affirmative vs. negative), the predicate mentioned in the sentence (above vs. below) and the "truth value" of the picture (true vs. false), we varied the delay with which the picture was presented after the sentences. For half of the participants, the delay was 0 ms whereas for the other half of the participants, the delay was 1500 ms.

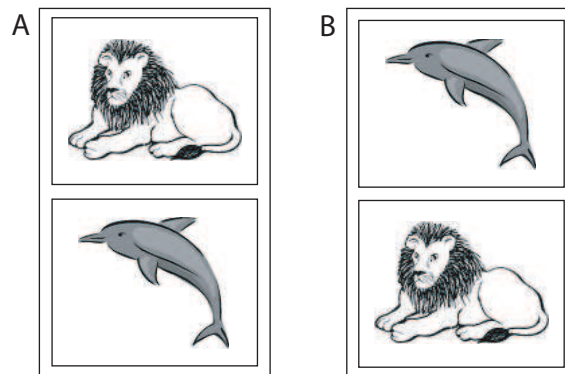


Figure 7. Pictures employed in the study in Kaup, Lüdtke, and Zwaan (2005).

We predicted that participants would be faster to respond to the pictures in the true condition than in the false condition after reading affirmative sentences in both delay conditions. The reason is that in the true affirmative condition, the picture matches the mental simulation that participants presumably construct when processing the sentence. For negative sentences, however, we predicted that the response time pattern would be affected by the delay with which the picture is presented after the sentences. In the short delay conditions, participants are likely still focussing on the negated situation. Thus, in this condition, we predicted shorter response times in the false than in the true conditions, because it is the false condition, where the picture matches the negated situation. For the long delay condition, in contrast, participants may have already shifted their attention towards the actual situation. In this condition, we therefore expected shorter response times in the true condition, because it is the true condition where the picture matches the actual simulation. In short, we expect to find a negation-by-truth-value interaction for the short delay, but a main effect of truth value for the long delay.

The results of the experiment are displayed in Figure 8. As was predicted, the short delay condition produced a significant negation-by-truth-value in-

teraction, whereas the long delay condition produced a main effect of truth value. Planned comparisons revealed that for affirmative sentences response times were shorter when the picture matched the described state of affairs (true) than when the picture mismatched this state of affairs (false) for both delays. In contrast, for the negative sentences, response times were not shorter when the picture matched the described situation. Rather, for the short delay, response times were significantly shorter when the picture matched the negated situation (false) than when the picture matched the actual situation. For the long delay, responses did not differ between the two picture conditions.

Thus, the results were exactly as expected on the basis of the experiential-simulations view of comprehension, except that in the negated-long-delay condition, responses were not faster when the picture matched the actual situation than when the picture matched the negated situation. This particular finding may suggest that some participants in some trials were still focussing on the negated situation whereas other participants in other trials were already focussing on the actual situation. Thus, although this null result was not predicted, it nevertheless is in line with the view that there is a point in time in the comprehension process where comprehenders switch their attention from the negated situation to the actual situation when processing negative sentences. This is an integral part of the experiential-simulations account of the sentence-verification results. Thus, according to this interpretation of the results, the 1500 ms delay was simply not long enough to produce pure match effects with respect to the actual situation (see Kaup, Lüdtke, Zwaan: in press, for similar results with other materials, tasks and delays).

3.3. Negation and availability

More recent studies have been concerned with the question of whether negation has an impact on the accessibility of information mentioned within its scope. In a study by MacDonald and Just (1989), participants were presented with sentences such as (15), and afterwards, the accessibility of the relevant concepts was measured by means of a probe-recognition or word-naming task. Probe words that had been mentioned in the negated phrase (*cookies*) yielded significantly longer response times than probe words mentioned in the non-negated phrase (*bread*) (for a similar effect with inferred concepts, see Lea and Mulligan 2002). MacDonald and Just took their results as sup-

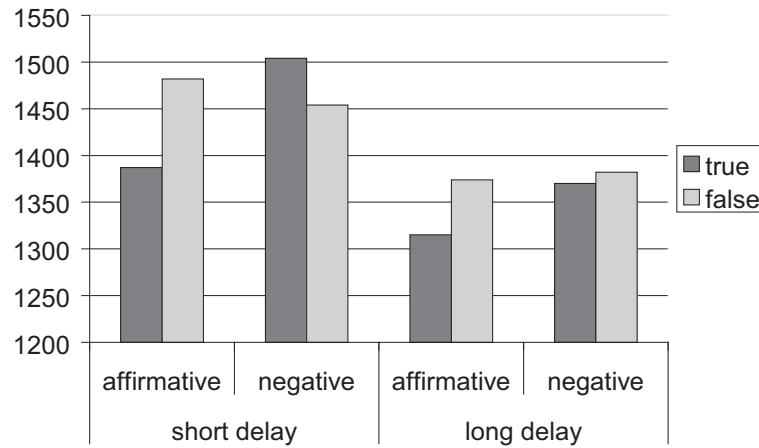


Figure 8. Mean response time as a function of negation, truth value, and delay in the recognition task employed in Kaup, Lüdtke, & Zwaan (2005).

port for the hypothesis that readers construct a propositional representation in which the negation operator encapsulates the information mentioned in its scope and thereby specifically reduces the accessibility of this information.

- (15) Almost every weekend Mary bakes some bread but no cookies for the children.

However, as was argued before, a result such as the one by MacDonald and Just is also in line with the two other theoretical frameworks, namely DRT and the experiential-simulation view of comprehension. DRT can attribute the response time difference to the fact that the non-negated probe word (*bread*) names an entity represented by a discourse referent in the accessible main DRS, whereas the negated probe word (*cookies*) does not. Assuming that discourse referents represented in the main DRS are more available in a probe-recognition task than discourse referents represented in a sub-DRS, DRT therefore predicts the exact response time difference that MacDonald and Just observed.

Similarly, according to the experiential-simulations view of comprehension, the simulation that is available after processing a sentence such as (15) is a simulation of the actual state of affairs described in the sentence. In this state of affairs there is a bread present but not a single cookie. Again, presup-

posing that concepts present in the simulation that is available at the time of testing are better available in a probe-recognition task than concepts absent from this simulation, the experiential-simulations view predicts the exact response time difference that MacDonald and Just observed.

The question arises how the three views can be distinguished empirically. As was briefly mentioned above, what is needed is a case where the negated probe word names an entity present in the resulting state of affairs whereas the non-negated probe word names an entity not present in the resulting state of affairs. Text (16), in which instead of a creation activity (e.g., baking) a destruction activity is being mentioned, provides an example.

- (16) Elizabeth is tidying out her drawers. She burns the old letters but not the photographs.

The letters and the photographs both constitute entities in the described world. However, as a result of the burning-down activity that is mentioned in the second sentence, only the entity mentioned in the negated phrase (i.e., photographs) is present in the resulting situation. Hence, whereas propositional theories of comprehension would predict that the type of activity mentioned in the negative sentences [creation as in (15) or destruction as in (16)] should not affect the observed accessibility difference between probe words in the negated and the non-negated conditions, both DRT and the experiential-simulations view of comprehension predict different effects for the two types of sentences. What matters for DRT is not really the type of activity but the question of whether or not discourse referents stand for entities in the discourse world. In (15) only the discourse referent introduced in the non-negated phrase represents an entity in the discourse world. In (16), in contrast, *both* of the two relevant discourse referents correspond to entities in the discourse world, and accordingly *both* are represented in the accessible main DRS². Thus, whereas DRT predicts a response time difference between the negated and the non-negated probe word in (15), no response time difference is predicted for (16). For the experiential-simulations view of comprehension, in contrast, it is indeed the type of activity that matters. For negative sentences with creation activities it is the non-negated entity that is present in the resulting situation, whereas for negative sentences with destruction activities it is the negated entity that is present. Hence, the experiential-simulations view predicts faster response times for the non-negated condition compared to the negated condition when the negative sentence mentions a creation ac-

tivity, but faster response times for the negated condition compared to the non-negated condition when the negative sentence mentions a destruction activity.

In order to test these predictions, participants were presented with narrative stories that contained negative sentences that mentioned either a creation or a destruction activity. A filler sentence followed that described the completion of the action without reference to one of the objects. Two-and a half seconds after processing the filler sentence participants were presented with the relevant probe words (see sample passages in Tables 1 and 2; cf. Kaup 1997, 2001). When the negative sentence mentioned a creation activities [as in (15)], probe words that had been mentioned in the negated phrase produced significantly faster response times than probe words that had been mentioned in the non-negated phrase (see Figure 9, Bars 1 and 2). Thus, this condition replicates the effect observed by MacDonald and Just (1989). When the negative sentences mentioned destruction activities [as in (16)], no response time difference was obtained (see Figure 9, Bars 3 and 4). This finding seems to correspond to the predictions of DRT. As was mentioned above, because in (16) both of the critical entities (letters and photographs) are introduced by definite noun phrases and therefore correspond to entities in the discourse world, both are represented in the accessible main DRS, and should accordingly not differ with respect to availability. However, the interpretation of the results in terms of DRT is called into question by the fact that introducing the relevant entities within definite noun phrases in sentences mentioning creation activities (see Table 3) does not eliminate the negation effect (see Figure 9, Bars 5 and 6).

If the DRT interpretation were correct, and the null result for sentences such as (16) were due to the fact that both discourse referents are represented in the main DRS, then sentences with creation activities in which the critical entities are being introduced within definite noun phrases should have produced a null result as well. The fact that a significant negation effect was observed for these sentences suggests that it is indeed the type of activity that is central to whether or not a negation effect is being observed. This in turn is what the experiential view suggests. But why then are the non-negated entities that are absent from the actual state of affairs (i.e., the letters) not less available than the negated entities that are present in this state of affairs (i.e., the photographs)? One possible reason may have to do with the fact that both entities were present in the state of affairs that held prior to the event mentioned in the negative sentences. Thus, prior to the burning-down event, both

letters and photographs were present. The same does not hold for the sentences with creation activities. In the indefinite version, the negated concept is not only absent from the resulting state of affairs but absent from all of the previous states of affairs as well. If Mary didn't bake any cookies then there are no cookies in the resulting situation, and without further knowledge, there is no reason to suspect that there were cookies prior to the baking event. In the definite version, the negated concept corresponds to an entity in the discourse world (otherwise it could not be referred to by means of a definite NP). However, in contrast to what was the case for the absent entities with destruction activities, this entity was never *physically* present in the situations described in the narrative. Rather it was implicitly introduced in the narrative context as some sort of mental entity or idea that the protagonist of the story had in mind. For instance, in the narrative in Table 3, the booklet with suggestions on what to build probably contains a construction plan for a church. Thus, the noun phrase *the church* in Table 3 refers to this idea or mental entity. Also, in contrast to what was the case for the absent entities with destruction activities, the absent entities in the definite version of creation activities were not the recipient of a particular action of the protagonist (e.g., burning down). Thus, it seems plausible to assume that the null result obtained for the destruction activities is due to the fact that the absent concepts are relatively highly accessible by virtue of (a) being physically present in the state of affairs that held prior to the event mentioned in the negation sentence, and (b) being the recipient of an action of the protagonist of the narrative.

Table 1. Sample Text for a narrative with creation activity

Title	Christmas Preparations.
Setting	(...) She knows that her uncle Carl really likes handcrafted things. For quite a while Sarah tried to come up with nice things she could make for him out of wood. Finally she bought some expensive oak lumber and got going.
Negation	Sarah is now building a chair but not a table for her uncle.
Completion	Sarah works for hours until she finally is finished.
Probe	CHAIR/TABLE

The interpretation of the results in terms of the experiential-simulations view of comprehension is further supported by a follow-up series of experiments in which negation and presence was manipulated within items (Kaup and Zwaan 2003). In these experiments participants were presented with narrative stories in which the penultimate sentence contained a color word. The color word was either mentioned within the scope of an explicit negation

Table 2. Sample Text for a narrative with destruction activity

Title	Cleaning up the attic.
Setting	Today is Peter's day off from work. Peter has decided to clean up the attic. For years, old furniture has been piling up in there. In order to create some space in the attic, Peter decides to chop up some of the furniture and burn it in the garden.
Negation	Peter burns the old bed but not the big cupboard.
Completion	After coming back from the garden, Peter goes to the attic and looks around happily.
Probe	BED / CUPBOARD

Table 3. Sample Text for a narrative with creation activity and definite noun phrases in the negation sentence

Title	John's ninth birthday.
Setting	John is turning nine years old today. He has already received a lot of nice presents. He is totally thrilled by the Lego bricks, which he got from his uncle. With the Lego bricks he got a booklet with suggestions on what to build. Now John is reading the booklet and is wondering what he could build next.
Negation	After a while he decides to build the castle but not the church.
Completion	Shortly later all his bricks are used up.
Probe	CHURCH / CASTLE

[(18) and (20)] or not [(17) and (19)]. Moreover, orthogonal to this variation, the corresponding color was either present in the described situation [(17) and (18)] or absent from this situation [(19) and ((20)]. After reading the sentence with the color term, participants were presented with a probe-recognition task. In experimental trials, the probe words corresponded to the color term that was mentioned in the sentence. Thus, in experimental trials the correct answer was always 'yes'. When the probe word was presented with a delay of 1500 ms after the sentence, participants were significantly faster to respond to the probe-recognition task when the color was present in the described situation than when the color was absent from this situation. Whether the color had been mentioned within the scope of an explicit negation or not, did not affect the response times³ (see Figure 10).

- (17) Susan liked the bike and she was glad that it had a blue frame.
[affirmative present]
- (18) Susan liked the bike, she only wished that it didn't have a blue frame.
[negative present]



Figure 9. Mean response time as a function of negation and type of activity. The experiments are reported in detail in Kaup (1997) [creation-indefinite and destruction-definite] and Kaup (2001) [creation-definite].

- (19) Susan liked the bike, she only wished that it had a blue frame.
[affirmative absent]
- (20) Susan liked the bike and she was glad that it didn't have a blue frame.
[negative absent]

The results of this experiment nicely correspond to the predictions of the experiential-simulations view of comprehension. From a certain point in the comprehension process on, when comprehenders have completed their simulations for the sentence under consideration, aspects of the linguistic form of the sentence are not relevant to the availability of concepts mentioned in the sentence. Rather, what matters is the content of the described situation. Concepts that are present in this state of affairs are better available than concepts absent from this state of affairs. Propositional theories and DRT cannot explain this result. According to both theories, the color term in the negated conditions is represented within the scope of a negation, and should therefore be relatively low in availability.

The interpretation of the results in terms of the experiential-simulations view was based on the second of the two proposed simulation steps, namely the focussing on the actual state of affairs. It was argued that once compre-

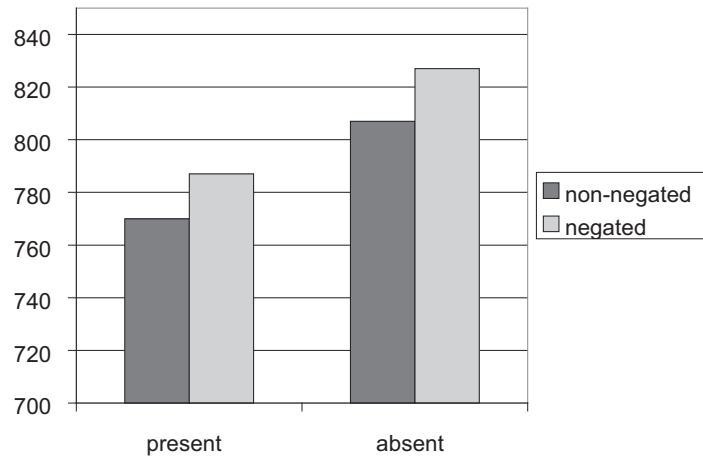


Figure 10. Mean probe-recognition times as a function of negation and presence in Experiment 2 of Kaup and Zwaan (2003).

henders have arrived at this second step, concepts that are present in the actual state of affairs should be better available than concepts that are absent from this state of affairs. Interpreting the results in terms of the second simulation step may at first sight seem plausible considering that probe words were presented after self-paced reading of the (affirmative and negative) sentences. In self-paced reading one would expect that comprehenders complete their simulations for a particular sentence before moving on to the next sentence or experimental task. However, as is well known in language processing research, this often is not the case. Comprehenders often seem to start processing the next text segment or experimental task while still being engaged in processing the previous one, to the effect that processing difficulty often spills over to subsequent text segments or tasks. Thus, it is not a-priori clear that response times in experimental tasks following self-paced reading would necessarily be affected by the content or nature of the *last* processing step. Indeed, in cases in which one postulates that different simulations are being in the focus of attention one after the other, one could expect that simulations that are in the focus of attention early in the comprehension process affect response times shortly after the processing of the sentence, whereas simulations that are in the focus of attention at later points in the comprehension process affect response times at longer delays. In line with this view, the re-

sults reported in this section were obtained in conditions in which the probe words were presented with delays of at least 1500 ms after the critical sentences. The only exception is the experiment by MacDonald and Just (1989) in which the probe words were presented without delay. However, it should be noted that the materials employed in this experiment (as well as the ones employed in Kaup 1997, 2001) were such that the negative sentences explicitly specified the actual state of affairs (bread present) prior to the negation (*no cookies*). Thus in this case, the actual state of affairs was in the focus of attention very early in the comprehension process, namely before comprehenders started creating the simulation of the negated state of affairs. Thus, it is not that surprising that effects reflecting the simulation of the *actual* state of affairs appeared early in the comprehension process for these materials. Figure 11 illustrates this point. When assuming that comprehenders start simulating the actual state of affairs when processing the first part of the sentence, one can expect to observe an availability advantage of the non-negated entity very early in the comprehension process (before comprehenders have started their simulations corresponding to the negative phrase), as well as very late in the comprehension process (when comprehenders have shifted their attention away from the negated state of affairs and back onto the actual state of affairs). For a visualization of the interpretations for the other materials, see Figures 12 and 13.

The next section will report findings that are relevant to the hypothesis that shortly after processing a negated sentence that does not explicitly specify the actual situation, comprehenders have available a simulation of the negated state of affairs, or in other words, a simulation that corresponds to the simulation that is being constructed when processing the corresponding sentences without negation.

3.4. Negation versus affirmation: Equivalence effects

A number of studies in the literature on negation have shown that early in the comprehension process, negative sentences often produce the exact same effects as the corresponding affirmative sentences without negation. Giora, Balaban, Fein, and Alkabets (2004), for instance, found that associates (e.g., *piercing*) were activated independent of whether the activating concept (e.g., *sharp*) was or was not negated in the sentence (e.g., *This instrument is sharp* versus *This instrument is not sharp*). Similarly, in an evaluative priming study

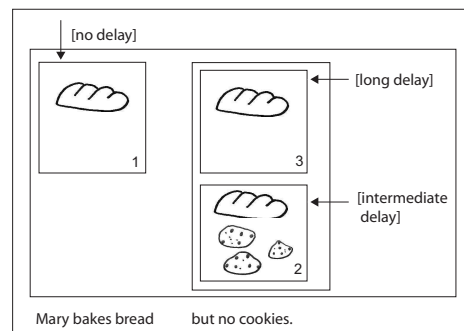


Figure 11. Availability testing at different points in the comprehension process. The non-negated concept (bread) should be better available than the negated concept (cookies) early and late in the comprehension process. Arabic numbers indicate the order in which the different simulations are attended to by the comprehender.

by Deutsch (2002, priming effects were independent of whether the primes were modified by an affirmative or negative determiner (e.g., prime: *a party* versus *no party*, see also Draine 1997).

These findings may of course reflect a fast-acting surface-level priming component of language processing as it is for instance proposed in the currently advocated versions of propositional theories of comprehension, namely resonance theory and the memory-based processing view (cf. Albrecht and Myers 1998; Kintsch 1988; McKoon and Ratcliff 1998). However, equivalence effects have also been observed with respect to effects that pose problems for propositional theories even in the affirmative case.

In a study by Zwaan et al. (2002) that was designed to test the experiential-simulations view for affirmative sentences, participants were presented with sentences such as (21) or (22), and afterwards saw a picture of the object mentioned in the verb phrase of the sentences. Participants judged as quickly as possible whether the object in the picture was mentioned in the sentence. For experimental trials, the correct response was always 'yes', but the picture either matched the implied shape of the object [outstretched wings for (21); folded wings for (22)] or not [folded wings for (21); outstretched wings for (22)]. Zwaan and colleagues found a strong match/mismatch effect. Response latencies were significantly shorter when there was a match between the sentence and the picture with respect to the object's shape than when there was a mismatch. This finding suggests that comprehenders routinely

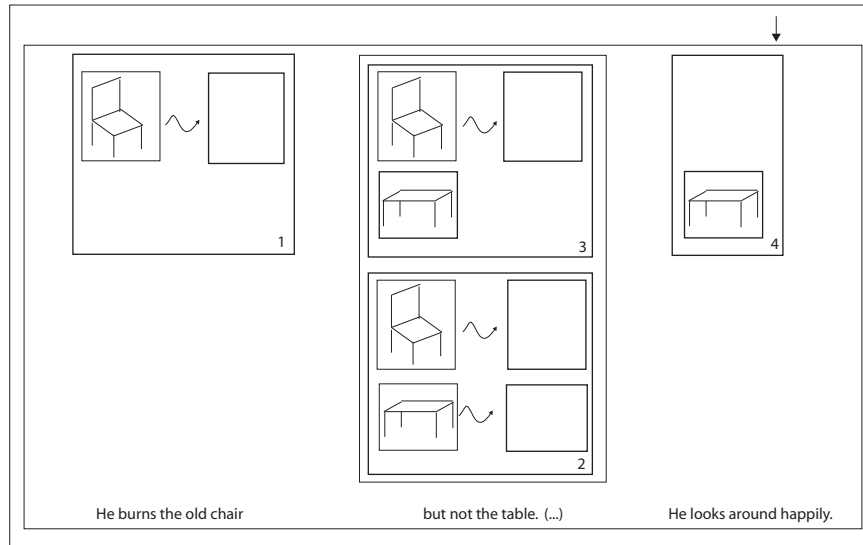


Figure 12. Hypothetical simulation processes carried out for destruction passages. The sequence object-arrow-empty_box is supposed to represent the burning-down event. The vertical arrow illustrates the time of testing. The finding that the two entities do not differ in availability at the time of testing, is attributed to the fact that both constitute physical entities that were present in the penultimate simulation. Arabic numbers indicate the order in which the different simulations are attended to by the comprehender.

infer the implied shapes of objects mentioned in a sentence, which in turn can be considered positive evidence for the idea that the processing of affirmative sentences of the type investigated by the authors triggers experiential simulations of the referent situations.

- (21) The ranger saw the eagle in the sky.
 (22) The ranger saw the eagle in the nest.

In a recent study we (Kaup, Yaxley, Madden, Zwaan, and Lüdtke submitted) adapted this paradigm to negative sentences. Participants were presented with the negative equivalents of the affirmative sentences employed by Zwaan et al. 2002, and 250 ms afterwards were presented with a picture that either matched the implied shape in the *negated* situation or not (see Figure 14). In two experiments we obtained a strong effect of the depicted state of affairs:

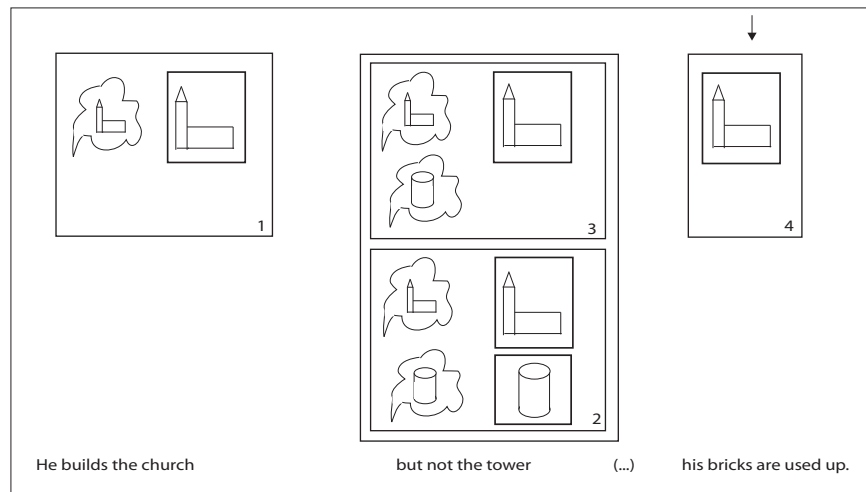


Figure 13. Hypothetical simulation processes carried out for creation passages with definite noun phrases. The boxes represent physical entities. The clouds represent mental entities. The vertical arrow illustrates the time of testing. The finding that the non-negated entity (church) is better available than the negated entity (tower) is attributed to the fact that the church is *physically* present in the final simulation whereas the tower is not, not even in the penultimate simulation. Arabic numbers indicate the order in which the different simulations are attended to by the comprehender.

Responses were faster when the picture matched the implied shape in the negated situation than when the picture mismatched this situation (see Figure 14). The difference in response times cannot be attributed to participants adopting a special strategy to ignore the negative particles in the experiment. The effect of the depicted situation was significant even if only those participants are taken into account who made hardly any mistakes on comprehension questions pertaining to the negative sentences in the experiment (see Kaup et al. submitted, for details). Thus, these results can be interpreted in terms of the experiential-simulations view, in that they suggest that comprehenders early in the comprehension process simulate the state of affairs that is being negated in the sentence. In other words, the results provide evidence for the first of the two proposed simulation steps, and thereby complement the results reported in the previous section that were interpreted as positive evidence for the second of the two simulation steps.

The interpretation of the results in terms of the experiential-simulations





Sentences		Depicted Situation	
		Negated	Other
There was no eagle in the sky.	(indefinite)		
The eagle was not in the sky.	(definite)		
There was no eagle in the nest.	(indefinite)		
There was no eagle in the sky.	(definite)		
Mean Response Time (in ms)			
	indefinite:	837	878
	definite:	847	894

Figure 14. Materials employed in Kaup, Yaxley, Madden, Zwaan, and Lüdtke (submitted), and response times as a function of definiteness and depicted situation.

view of comprehension is further bolstered by the fact that employing the same paradigm with longer delays (750 ms and 1500 ms) and contradictory predicates (e.g., *open / closed*) leads to different effects (see Figure 15, cf. Kaup et al. in press). Under these conditions, a main effect of the depicted situation is observed, with response latencies being shorter when the picture shows the actual state of affairs than when the picture shows the negated/other state of affairs. This response time pattern is in line with the view that at longer delays participants have available a simulation of the *actual* state of affairs. However, this main effect was qualified by a three way interaction of delay, polarity (affirmative vs. negative) and depicted situation, which seems to reflect the fact that the advantage of the picture representing the actual situation is mainly due to the 750 ms delay condition for affirmative sentences but due to the 1500 ms delay condition for negative sentences. Thus, it seems that for negative sentences, the actual simulation is not fully developed at the intermediate delay, such that an advantage of the picture representing the actual state of affairs shows up at the long delay only. For affirmative sentences, the simulation of the actual state of affairs constitutes the first simulation step, and accordingly, the simulation is fully developed at the intermediate delay. At the long delay, participants have probably already turned their attention away from the simulation, such that it does not matter which situation is depicted in the picture.

It could be argued that the differences in results obtained in the two studies with short and long delays are not due to the differences in the delays





Sentences			Depicted Situation	
			Actual	Neg/Other
The umbrella was closed. The umbrealla was not open.	(affirmative) (negative)			
The umbrella was open. The umbrella was not closed.	(affirmative) (negative)			
Mean Response Time (in ms)	750 ms	aff:	619	642
		neg:	643	648
	1500 ms	aff:	624	626
		neg:	611	634

Figure 15. Materials employed in Kaup, Lüdtke, & Zwaan (in press), and response times as a function of delay, polarity (affirmative / negative) and depicted situation.

but rather to properties of the predicates in the experimental sentences. In the study in which the pictures were presented after a 250 ms delay, the predicates were locational specifications (e.g., to be in the nest / to be in the sky), the negation of which usually does not provide specific information about the actual location of the target entity. In the study in which the pictures were presented with longer delays (750 ms and 1500 ms), the predicates were contradictory state descriptions (to be open / to be closed), the negation of which does provide specific information about the actual state of the critical entity. At first sight, this seems to suggest that participants represent the negated state of affairs for sentences with predicates of the first type, and the actual state of affairs for sentences with predicates of the second type. Such a view comes close to assumptions made by Mayo et al. (2004). However, an account based solely on the type of predicate cannot explain why the two delay conditions in Kaup et al. (in press) produced different results despite the fact that they employed the exact same contradictory predicates. Thus, this result seems to rule out the possibility that participants immediately focus their attention on a simulation of the actual state of affairs when processing negative sentences with contradictory predicates. However, this result leaves open the possibility that comprehenders of isolated sentences with non-contradictory predicates (e.g., *There is no eagle in the sky*) do not automatically shift their attention towards the actual state of affairs from a certain point in the compre-

hension process on. In principle it seems conceivable that this attention shift towards the actual state of affairs is dependent on certain conditions, such as that the negative sentences are embedded into a longer narrative context or that the negative sentences imply inferences concerning the actual state of affairs (which is the case with contradictory predicates but not with non-contradictory predicates).

The view that the delay manipulation is a decisive variable in this case, is also supported by the results of a recent study by Hasson and Glucksberg (in press): Participants were presented with a lexical-decision task after reading affirmative and negative metaphors (e.g., *My lawyer is / is not a shark*). When presented after a 1000 ms delay, probes related to the affirmative version of the metaphor (e.g., *vicious*) led to faster response times after affirmative than after negative metaphors, whereas probes related to the negative version of the metaphor (e.g., *gentle*) led to faster response times after negative than after affirmative metaphors (at least for some types of metaphors). After shorter delays (150ms and 500 ms) this Prime x Target interaction was not significant. Under these conditions, probes related to the affirmative version of the metaphor seemed to be facilitated after both the negative and the affirmative version of the metaphor.

3.5. Long-term effects of negation

The empirical results reported in the previous sections of this chapter were relevant to the question of how negative information is captured in the working-memory representations created in language comprehension. The respective studies were concerned with the availability of information *during* language comprehension, or in other words with the short-term impact of negation. There are also a few studies on the processing of negation that address the long-term impact of negation. These studies investigated whether negative sentences differ from affirmative sentences with respect to how well they are recalled or recognized, and if so, whether there are differences between different types of negations. The results indicated that there are indeed differences between negative and affirmative sentences, as well as between different types of negations: Compared to affirmative sentences, memory performance with negative sentences was generally poor (Boysson-Bardies 1970; Engelkamp and Hörmann 1974; Engelkamp, Merdian, and Hörmann 1972; Fillenbaum 1966; Hörmann 1971; Mayo et al. 2004). Obviously, this finding is in line

with all three of the discussed representational accounts: According to all accounts, the memory representations created for negative sentences are more complex than the ones created for affirmative sentences, and accordingly, processes that operate on these representations are naturally more error-prone in the negative than in the affirmative case. Memory performance for negative sentences proved to be positively affected by the ease with which alternatives to the negated state of affairs came to mind (Engelkamp and Hörmann 1974; Hörmann 1971). Although in principle this finding can be explained by all three representational accounts, it seems particularly well in line with the experiential-simulations view of negation, according to which comprehenders routinely simulate the actual state of affairs when processing negative sentences.

In addition to these more global differences in memory performance between affirmative and negative sentences, the exact nature of the errors obtained with negative sentences seems relevant for empirically distinguishing between the three representational accounts: For instance, theories assuming an explicit representation of negation (propositional theories and DRT) predict that recall errors with negative sentences should often reflect a loss of the negation marker, such that negative sentences are mis-recalled as the corresponding affirmative sentences without negation (e.g., *not red* being recalled as *red*). The experiential-simulations view, in contrast, does not predict these errors, because the simulation of the negated state of affairs is presumably kept in a separate representational system. Unfortunately, the empirical evidence regarding this prediction is inconsistent. Whereas Mayo et al. (2004) obtained these *dissociation errors* in 38% of the cases with uni-polar adjectives (e.g., *not responsible*), a number of other studies found dissociation errors only in far less than 10 % of the cases (Boysson-Bardies 1970; Engelkamp and Hörmann 1974; Engelkamp et al. 1972; Hörmann 1971). However, consistent results were obtained with respect to two other types of recall errors: Translation errors (e.g., *not open* being mis-recalled as *closed*) were observed with sentences containing contradictory negation (Fillenbaum 1966; Mayo et al. 2004), and errors with respect to the position of the negation marker in the surface structure of the sentence were observed with sentences containing a focussing negation. Sentences with a focussing negation (e.g., *Nicht der Hund hat den Knochen gestohlen* [*Not the dog stole the bone*]; *Der Hund hat nicht den Knochen gestohlen* [*The dog stole not the bone*]) were often found to be mis-recalled as the corresponding sentences with non-focussing negation (e.g., *Der Hund hat den Knochen nicht gestohlen* [*The*

dog did not steal the bone.]; Engelkamp and Hörmann 1974; Engelkamp et al. 1972; Hörmann 1971). Both error types are well in line with all three representational accounts. Propositional theories can attribute translation errors with contradictory negation to the fact that comprehenders draw the respective inference when processing the negation, and then erroneously base their later recall on these inferences instead of on the explicitly given statement. Similarly, according to the experiential-simulations view, translation errors arise when recall is erroneously based on the simulations of the actual states of affairs instead of on the simulation of the negated state of affairs. Errors with respect to the position of the negation marker in the surface structure of the sentence can be accounted for by propositional theories on the basis of the assumption that the semantic representation of a sentence with focussing negation (e.g., *Not the dog stole the bone*) consists of an unspecific negative proposition ('¬ [the dog stole the bone]') plus an affirmative proposition which specifies the adequate alternatives ('some other entity stole the bone'; see Rooth 1992, 1996). If the additional affirmative proposition gets lost, focussing negation will be mis-recalled as non-focussing negation. The experiential-simulations view of negation also has a natural way of accounting for this type of error: The simulation of the negated state of affairs does not differ for focussing and non-focussing negation. A sentence such as *Not the dog stole the bone* (focusing negation) leads to a simulation of the dog stealing the bone in the auxiliary system just as the corresponding sentence with non-focusing negation does (e.g., *The dog did not steal the bone*). Differences between focusing and non-focusing negation only arise with respect to the simulation of the actual state of affairs: Whereas in the focussing version, the simulation of the actual state of affairs contains some other entity that steals the bone, no such entity is represented in the non-focusing version. Thus, if comprehenders recall the sentence based solely on their representations in the auxiliary system, focussing negation will be mis-recalled as non-focussing negation.

4. Conclusions

The present chapter was concerned with the question of what psycholinguistic negation research tells us about the nature of the working-memory representations constructed in language comprehension. Three theoretical accounts were considered, namely propositional theories of comprehension,

discourse-representation theory, and the experiential-simulations view of comprehension. These three accounts differ with respect to assumptions concerning general representational issues in language comprehension, as well as with respect to assumptions concerning the processing and representation of negation. Accordingly, negation research can be expected to be fruitful in distinguishing empirically between the different representational assumptions. Four groups of empirical findings were discussed. The first group of findings indicated that negative sentences are harder to process than affirmative sentences, whereby this difference in processing difficulty diminishes in case the negative sentences are presented in pragmatically felicitous contexts. As was argued in detail above, this finding is in line with all three of the discussed representational accounts. The second group was concerned with the question of why negation interacts with the truth value of sentences in sentence-picture verification tasks. According to the classical propositional accounts of this finding, the differences in response time reflect differences in the number of steps that are required to compare a propositional representation of the sentence with a propositional representation of the picture. However, as was argued, the experiential view of comprehension offers an alternative account, according to which the differences in response time reflect differences in the degree to which the picture is primed by the simulations that comprehenders have available at the time of testing. Indeed, the fact that a negation-by-truth-value interaction effect was observed with an experimental task that does not require verification, provides indirect support for this alternative account. The third group of findings was concerned with the question of whether, and if so by which mechanism, negation has an impact on the availability of text information. In contrast to what was predicted by propositional theories and DRT, availability was independent of whether or not a particular concept was mentioned within a negative or an affirmative phrase. Rather the decisive variable seemed to be the content of the actual situation. This finding favors the experiential-simulations view of comprehension, according to which comprehenders of negative sentences eventually focus on a simulation of the *actual* state of affairs in which only those entities are present and highly available that are present in the described state of affairs. The fourth group of findings provided evidence that negation and affirmation often produce equivalent effects, at least shortly after the processing of the corresponding linguistic material. Although all three accounts can in principle account for equivalence effects between negation and affirmation, particular results clearly favored the experiential-simulations view. Both

propositional theories and DRT would need additional post-hoc assumptions concerning the number and type of inferences that are drawn online in order to explain why a picture of an eagle with outstretched wings should be easier to process after a sentence such as *There was no eagle in the sky* than after a sentence such as *There was no eagle in the nest*. The experiential-simulations view, in contrast, cannot only explain this effect but predicts it. Thus, taken together the reported findings seem to favor the experiential-simulations view of comprehension. Admittedly, on an individual basis, only a few of the findings provide clear cut support for predictions deduced from this view. In many cases, the results neither corresponded to the predictions deduced from propositional theories or DRT, nor to the predictions deduced from the experiential view. However, in these cases, the results nevertheless favored the experiential view, as the deviations between predictions and results concerned details rather than global aspects of the predictions deduced from this view. For instance, with respect to the studies investigating the impact of negation on the availability of (negated and non-negated) concepts in sentences with creation versus destruction activities, the experiential view predicted an interaction of activity type and negation: Negated entities were predicted to be less available than non-negated entities for sentences with creation activities, whereas negated entities were predicted to be better available than non-negated entities for sentences with destruction activities. For sentences with creation activities this prediction was borne out by the data. For sentences with destruction activities, however, no response time difference was found. Thus the predictions were only partly supported. Yet, the important point is that the type of activity that was being mentioned in the negative sentences indeed had an impact on the negation effect. This impact was explicitly predicted by the experiential-simulations view. For propositional theories and DRT, in contrast, there does not seem to be any reason to expect such an impact. Thus, on a global level, the results supported the predictions of the experiential view. The fact that in the details there were deviations between predictions and results simply suggests that matters are more complicated than was assumed at first. For the study at hand, for instance, it was probably a simplification to assume that the availability of a discourse entity only depends on whether or not it is present in the *final* simulation of the actual state of affairs. When this assumption is corrected post-hoc, and it is assumed that the availability of a discourse entity also depends on whether or not it was present in a previous simulation of the actual state of affairs, the results are well in line with the experiential view.

To conclude, the existent psycholinguistic findings in negation research

clearly favor the experiential-simulations view of comprehension. In some cases the findings provide direct support for this view, and in others the findings simply fit better with the central assumptions of this view than with the central assumptions of the concurrent views. In these latter cases, additional post-hoc assumptions allowed to explain the results in terms of the experiential-simulations view. Clearly, future studies are necessary to evaluate these post-hoc assumptions. For the time being, however, it can be concluded that comprehending a text is tantamount to mentally simulating the state of affairs described in the text. Accordingly, as Johnson-Laird has put it already in 1983, "A major function of language is thus to enable us to experience the world by proxy" (p. 471).

References

- Albrecht, Jason E. and Jerome L. Myers
 1998 Accessing distant text information during reading: Effects of contextual cues. *Discourse Processes* 26: 87–107.
- Arroyo, Francisco. V.
 1982 Negatives in context. *Journal of Verbal Learning and Verbal Behavior* 21: 118–126.
- Barsalou, Lawrence W.
 1999 Perceptual symbol systems. *Behavioral and Brain Sciences* 22: 577–660.
- Carpenter, Patricia A.
 1973 Extracting information from counterfactual clauses. *Journal of Verbal Learning and Verbal Behavior* 12: 512–521.
- Carpenter, Patricia A. and Marcel A. Just
 1975 Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review* 82: 45–73.
- Clark, Herbert H. and William G. Chase
 1972 On the process of comparing sentences against pictures. *Cognitive Psychology* 3: 472–517.
- Cornish, E. R.
 1971 Pragmatic aspects of negation in sentence evaluation and completion tasks. *British Journal of Psychology* 62: 505–511.
- de Boysson-Bardies, Benedicte
 1970 Syntax and semantics in memorization of negation. In *Advances in Psycholinguistics*, Giovanni B. F. d'Arcais and Willem M. Levelt (eds.), 237–246. Amsterdam: North-Holland Publishing Company.
- de Villiers, Jill G. and Helen B. T. Tager-Flusberg
 1975 Some facts one simply cannot deny. *Child Language* 2: 279–286.

- Deutsch, Roland
2002 *What does it take to negate? How processing negated information affects cognition and behavior*. Ph. D. diss., Department of Psychology, Julius-Maximilians-Universität Würzburg.
- Donaldson, Margaret
1970 Developmental aspects of performance with negatives. In *Advances in Psycholinguistics*, Giovanni B. F. d'Arcais and Willem M. Levelt (eds.), 369–412. Amsterdam: North-Holland Publishing Company.
- Draine, Sean C.
1996 *Analytic limitations of unconscious language processing*. Ph. D. diss., University of Washington.
- Eiferman, Rivka R.
1961 Negation, a linguistic variable. *Acta Psychologica* 18: 258–273.
- Engelkamp, Johannes and Hans Hörmann
1974 The effect of non-verbal information on the recall of negation. *Quarterly Journal of Experimental Psychology* 26: 98–105.
- Engelkamp, Johannes, Franz Merdian, and Hans Hörmann
1972 Semantische Faktoren beim Behalten der Verneinung von Sätzen. *Psychologische Forschung* 35: 93–116.
- Fillenbaum, Samuel
1966 Memory for gist: Some relevant variables. *Language and Speech* 9: 217–227.
- Giora, Rachel, Noga Balaban, Ofer Fein, and Inbar Alkabets
2004 Negation as positivity in disguise. In *Figurative Language Comprehension: Social and Cultural Influences*, Herbert L. Colston and Albert N. Katz (eds.), 233–258. Hillsdale, NJ: Erlbaum.
- Givon, Talmy
1978 Negation in language: Pragmatics, functions, ontology. In *Syntax and Semantics*, Peter Cole (ed.), 66–112. Vol. 9. New York: Academic Press.
- Glenberg, Arthur M.
1997 What memory is for. *Behavioral and Brain Sciences* 20: 1–55.
- Glenberg, Arthur M. and Michael P. Kaschak
2002 Grounding language in action. *Psychonomic Bulletin & Review* 9: 558–565.
- Glenberg, Arthur M., Marion Meyer, and Karen Lindem
1987 Mental models contribute to foregrounding during text comprehension. *Journal of Memory and Language* 26: 69–83.
- Glenberg, Arthur M. and David A. Robertson
1999 Indexical understanding of instructions. *Discourse Processes* 28: 1–26.
- Glenberg, Arthur M., David A. Robertson, Jennifer L. Jansen, and Mina C. Johnson-Glenberg
1999 Not propositions. *Journal of Cognitive Systems Research* 1: 19–33.
- Gough, Philip B.
1965 Grammatical transformations and speed of understanding. *Journal of Verbal Learning and Verbal Behavior* 4: 107–111.
1966 The verification of sentences: The effects of delay of evidence and sentence length. *Journal of Verbal Learning and Verbal Behavior* 5: 492–496.

- Graesser, Arthur C., Murray Singer, and Tom Trabasso
 1994 Constructing inferences during narrative text comprehension. *Psychological Review* 101: 371–395.
- Greene, Judith M.
 1970 The semantic function of negatives and passives. *British Journal of Psychology*, 61 (1), 17–22.
- Hasson, Uri and Sam Glucksberg
 in press Does understanding negation entail affirmation? *Journal of Pragmatics*.
- Hörmann, Hans
 1971 Semantic factors in negation. *Psychologische Forschung*, 35: 1–16.
- Horn, Laurence R.
 1989 *A natural history of negation*. Chicago: Chicago University Press.
- Johnson-Laird, Philip N.
 1983 *Mental models*. Cambridge, MA: Harvard University Press.
- Jones, Sheila
 1966 The effect of a negative qualifier in an instruction. *Journal of Verbal Learning and Verbal Behavior* 5: 497–501.
 1968 Instructions, self-instructions and performance. *Quarterly Journal of Experimental Psychology* 20: 74–781.
- Just, Marcel A. and Patricia A. Carpenter
 1971 Comprehension of negation with quantification. *Journal of Verbal Learning and Verbal Behavior* 10: 244–253.
- Just, Marcel A. and Herbert H. Clark
 1973 Drawing inferences from the presuppositions and implications of affirmative and negative sentences. *Journal of Verbal Learning and Verbal Behavior*, 21–31.
- Kamp, Hans
 1981 A theory of truth and semantic representation. In *Formal Methods in the Study of Language*, Jeroen Groenendijk, Theo Janssen and Martin Stokhof (eds.), 277–322. Pt. 1. Amsterdam: Mathematisch Centrum.
- Kamp, Hans and Uwe Reyle
 1993 *From Discourse to Logic*. Dordrecht: Kluwer Academic Publishers.
- Kaup, Barbara
 1997 The processing of negatives during discourse comprehension. In *Proceedings of the Nineteenth Conference of the Cognitive Science Society*, Michael G. Shafto and Pat Langley (eds.), 370–375. Mahwah, NJ: Erlbaum.
 2001 Negation and its impact on the accessibility of text information. *Memory & Cognition* 20: 960–967.
- Kaup, Barbara, Jana Lüdtker, and Rolf A. Zwaan
 2005 Effects of negation, truth value, and delay on picture recognition after reading affirmative and negative sentences. In *Proceedings of the 27th Annual Conference of the Cognitive Science Society*, Lawrence W. B. Bruno G. Bara and Monica Bucciarelli (eds.), 1114–1119. Hillsdale, NJ: Lawrence Erlbaum.
- Kaup, Barbara, Jana Lüdtker, and Rolf A. Zwaan
 in press Processing negated sentences with contradictory predicates: Is a door that is not open mentally closed? *Journal of Pragmatics*.

- Kaup, Barbara, Richard H. Yaxley, Carol J. Madden, Rolf A. Zwaan, and Jana Lüdtké
submitted *Experiential simulations of negated text information*. Manuscript submitted
for publication.
- Kaup, Barbara and Rolf A. Zwaan
2003 Effects of negation and situational presence on the accessibility of text infor-
mation. *Journal of Experimental Psychology: Learning, Memory, and Cogni-
tion* 29: 439–446.
- Kaup, Barbara, Rolf A. Zwaan, and Jana Lüdtké
in press The experiential view of language comprehension: How is negation repre-
sented? In *Higher Level Language Processes in the Brain: Inference and com-
prehension processes*, Franz Schmalhofer and Charles A. Perfetti (eds.). Mah-
wah, NJ: Erlbaum.
- Kelter, Stephanie
2003 Mentale Modelle. *Psycholinguistik - ein Internationales Handbuch*, Gert Rick-
heit, Theo Herrmann and Werner Deutsch (eds.), 505–517. Berlin: Walter de
Gruyter.
- Kelter, Stephanie, Barbara Kaup, and Berry Claus
2004 Representing a described sequence of events: A dynamic view of narrative
comprehension. *Journal of Experimental Psychology: Learning, Memory, and
Cognition* 30: 451–464.
- Kintsch, Walter
1988 The role of knowledge in discourse comprehension: A construction-integration
model. *Psychological Review* 59: 163–182.
- Kintsch, Walter and Teun A. van Dijk
1978 Toward a model of text comprehension and production. *Psychological Review*
85: 363–394.
- Lea, R. Brooke and Elizabeth J. Mulligan
2002 The effect of negation on deductive inferences. *Journal of Experimental Psy-
chology: Learning, Memory, and Cognition* 28: 303–317.
- MacDonald, Maryellen C. and Marcel A. Just
1989 Changes in activation levels with negation. *Journal of Experimental Psychol-
ogy: Learning, Memory, and Cognition* 15: 633–642.
- MacLeod, Colin M., Eearl B. Hunt, and Nancy N. Mathews
1978 Individual differences in the verification of sentence-picture relationships. *Jour-
nal of Verbal Learning and Verbal Behavior* 17: 493–507.
- MacWhinney, Brian
1999 The emergence of language from embodiment. In *The emergence of language*,
Brian MacWhinney (Ed.), 213–256. Mahwah, New Jersey: Lawrence Erlbaum
Associates, London.
- Mayo, Ruth, Yaacov Schul, and Eugene Burnstein
2004 "I am not guilty" vs "I am innocent": Successful negation may depend on the
schema used for its encoding. *Journal of Experimental Social Psychology* 40:
443–449.
- McKoon, Gail and Roger Ratcliff
1992 Inference during reading. *Psychological Review* 99: 440–466.

- 1998 Memory-based language processing: Psycholinguistic research in the 1990s. *Annual Review of Psychology* 49: 25–42.
- Morrow, Daniel G., Gordon H. Bower, and S. L. Greenspan
1990 Situation-based inferences during narrative comprehension. In *The Psychology of Learning and Motivation: Inferences and Text Comprehension*, Arthur C. Graesser and Gordon H. Bower (eds.), 123–135. Vol. 25. New York: Academic Press.
- Pulvermüller, Friedemann
2002 A brain perspective on language mechanisms: From discrete neuronal ensembles to serial order. *Progress in Neurobiology* 67: 85–111.
- Pulvermüller, Friedemann, Markus Haerle, and Friedhelm Hummel
2001 Walking or talking?: Behavioral and neurophysiological correlates of action verb processing. *Brain and Language* 78: 143–168.
- Rooth, Mats
1992 A theory of focus interpretation. *Natural Language Semantics* 1: 75–116.
1996 Focus. In *Handbook of Contemporary Semantic Theory*, Shalom Lappin (Ed.), 271–297. Oxford: Blackwell.
- Stanfield, Robert A. and Rolf A. Zwaan
2001 The effect of implied orientation derived from verbal context on picture recognition. *Psychological Science* 12: 153–156.
- Trabasso, Tom, Howard Rollins, and Edward Shaughnessy
1971 Storage and verification stages in processing concepts. *Cognitive Psychology* 2: 239–289.
- van Dijk, Teun A. and Walter Kintsch
1983 *Strategies of discourse comprehension*. New York: Academic Press.
- Wales, Roger and Robert Grieve
1969 What is so difficult about negation? *Perception and Psychophysics* 6: 327–332.
- Wason, Peter C.
1959 The processing of positive and negative information. *Quarterly Journal of Experimental Psychology* 11: 92–107.
1961 Response to affirmative and negative binary statements. *British Journal of Psychology* 52: 133–142.
1965 The contexts of plausible denial. *Journal of Verbal Learning and Verbal Behavior* 4: 7–11.
- Wason, Peter C. and Sheila Jones
1963 Negatives: Denotation and connotation. *British Journal of Psychology* 54: 299–307.
- Zwaan, Rolf A.
2004 The immersed experiencer: Toward an embodied theory of language comprehension. In *The Psychology of Learning and Motivation*, Brian H. Ross (Ed.), 35–62. Vol. 44. New York: Academic Press.
- Zwaan, Rolf A. and Gabriel A. Radvansky,
1998 Situation models in language comprehension and memory. *Psychological Bulletin* 123: 162–183.

- Zwaan, Rolf A., Robert A. Stanfield, and Richard H. Yaxley
2002 Language comprehenders mentally represent the shapes of objects. *Psychological Science* 13: 168–171.