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Effects of Negation and Situational Presence on the Accessibility of Text Information

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In 2 experiments, participants read narratives containing a color term that was mentioned either within the scope of an explicit negative or not, and with the described situation being such that the color was either present or not. Accessibility of the color term was measured by means of a probe-recognition task either 500 ms (Experiment 1) or 1,500 ms (Experiment 2) after participants read the sentence mentioning color. After the 500-ms delay, the accessibility of the color term was influenced by the structure of the sentence. After the 1,500-ms delay, the accessibility was influenced by the content of the described situation. These results are consistent with the view that comprehenders construct a linguistic representation of the text as well as a situation model in which only present properties are represented. An alternative account, according to which comprehenders only construct a perceptual simulation of the described situation, is discussed.

In language comprehension research, negation is usually considered an operator that shifts the discourse focus away from the information mentioned within its scope and thereby reduces the accessibility of this information (e.g., Lea & Mulligan, 2001; MacDonald & Just, 1989; see also Paterson, Sanford, Moxey, & Dawydiak, 1998; Sanford, Moxey, & Paterson, 1996). For instance, when readers are presented with sentences such as Sentence 1, below, and immediately afterward make a word recognition or naming response, they are quicker to respond to the probe word *bread* than to the probe word *cookies*, which seems to suggest that the negation marker *no* reduces the accessibility of *bread*, a noun mentioned within the operator's scope (MacDonald & Just, 1989).

1. Every weekend, Mary bakes bread but no cookies for the children.

Independent of the validity of this claim, however, there is another potential explanation for this result. It is conceivable that it is not the negation operator that is responsible for the reduced accessibility of the probe word *bread* but rather a situational variable. In the situations described in Sentence 1, there is bread present but not a single cookie. Assuming that language comprehension involves the construction of a representation in which only those entities that are present in the described state of affairs are represented, the accessibility difference after one reads sentences such as Sentence 1 can be attributed to the fact that this representation contains a token for bread but no token for cookies (Kaup, 1997, 2001).

Distinguishing empirically between these two explanations is important because they are based on very different assumptions about the kind of representations involved in language comprehension. The first explanation, according to which the scope of the negation operator is the relevant variable, rests on the assumption that readers construct a linguistic representation of the sentence—for instance, a propositional representation. In a propositional representation, negation is an explicitly represented operator that takes a whole proposition in its scope. Thus, the sentence *Mary bakes bread but no cookies* is represented as "bakes[Mary, bread] and NOT[bakes[Mary, cookies]]," and it is conceivable that *cookies* is less accessible than *bread* after one reads this sentence, simply because it is encapsulated by the negation operator (MacDonald & Just, 1989).

The second explanation, according to which the situational content is the relevant variable, rests on the assumption that comprehension is tantamount to the construction of a situation model (Van Dijk & Kintsch, 1983). A situation model is a representation of the situation described by the linguistic input and thereby differs in important ways from a propositional representation. Whereas a propositional representation is a mental description of the state of affairs under consideration, a situation model represents the state of affairs itself. In other words, the components of a situation model are not propositions describing particular aspects of the state of affairs but the entities, properties, and relations that make up the state of affairs (Zwaan & Radvansky, 1998). Thus, a situation model contains tokens only for entities and properties that are actually present in the described state of affairs (Anderson, Garrod, & Sanford, 1983; Carreiras, Carriedo, Alonso, & Fernandez, 1997; Glenberg, Meyer, & Lindem, 1987; Zwaan, Madden, & Whitten, 2000). Accordingly, the situation model

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constructed for Sentence 1 contains a token for bread but no token for cookies, which might well be the cause of the observed difference in accessibility.

To evaluate these two explanations, we conducted two experiments. Participants read narrative texts that contained a color word in the penultimate sentence (e.g., Sentences 2–5). This color word was mentioned either within an affirmative (Sentences 2 and 4) or within a negative phrase (Sentences 3 and 5). Moreover, the corresponding color was either present in the described situation (Sentences 2 and 3) or absent from it (Sentences 4 and 5). The accessibility of the color term was measured by means of a probe-recognition task after the end of the sentence. Thus, in the examples below, the probe word is *pink*.

2. Sam was relieved that Laura was wearing her pink dress.
3. Sam wished that Laura was not wearing her pink dress.
4. Sam wished that Laura was wearing her pink dress.
5. Sam was relieved that Laura was not wearing her pink dress.

According to the propositional explanation, negation functions as an accessibility-reducing mechanism, and, thus, we would expect to find that people have longer latencies for the color word after reading Sentences 3 and 5 than after reading Sentences 2 and 4. In contrast, according to the situation-model explanation, the relevant variable is whether the color is present in the described situation, and, thus, we would expect to find longer latencies after people read Sentences 4 and 5 than after they read Sentences 2 and 3.

Most researchers investigating situation-model construction during language comprehension assume that comprehenders construct a situation model in addition to a propositional representation of the text (for an overview, see Fletcher, 1994). On the basis of these multilevel accounts, it could be proposed that both variables have an impact on the accessibility of text information, but at different levels of representation. In fact, the results of an earlier study, in which negation and situational presence were varied orthogonally to each other, are consistent with this view (Kaup, 2001). Participants were presented with narratives that contained negation sentences mentioning either constructing or destroying activities (e.g., *John was building the castle but not the church*; *Sarah was burning the letters but not the photographs*, respectively). The negation effect proved to be significantly larger for the passages with constructing activities than for the passages with destroying activities. This differential result was interpreted as reflecting the fact that negation and situational presence reinforce each other for passages with constructing activities (the nonnegated entity is present in the resulting situation; the negated entity is not), whereas the two variables are counteracting for passages with destroying activities (the negated entity is present in the resulting situation). Thus, the findings of this study are consistent with the view that comprehenders construct a propositional representation in which negation is represented explicitly as well as a situation model in which only those entities and properties are represented that are present in the described situation. This multilevel explanation, however, was clearly post hoc in this study.

Studies explicitly dealing with the different levels of representation constructed during comprehension have provided evidence that propositional representations are available earlier than are situation models in the comprehension process (e.g., Schmalhofer & Glavanov, 1986). Thus, if indeed both variables have an impact on the accessibility of text information, their impact should vary with the delay at which accessibility of text information is measured. The impact of the negation operator should be stronger after a short than after a long delay, and the impact of the situational content should be stronger after a long than after a short delay. Accordingly, we varied the delay with which the probe was presented after the penultimate sentence of the narratives. In Experiment 1, the probe was presented with a 500-ms delay; in Experiment 2, it was presented with a 1,500-ms delay.

Experiment 1

Method

Participants. Forty-eight students at Florida State University participated in the experiment for course credit.

Materials. The materials consisted of 76 stories, 24 of which were used as experimental items, and 52 of which were used as filler items. The experimental items were constructed according to the following schema (see Appendix): After a short introductory section, the protagonist was described as thinking about a particular object. In the eighth sentence (target sentence), a particular color was mentioned in the context of describing the protagonist's attitude toward this object. There were four different versions of this target sentence, which differed with respect to two variables. The color word was mentioned either within an affirmative or within a negative phrase, and the color either was or was not the color of the target object. In all versions, the color word was the penultimate word of the sentence. Furthermore, the color word was never mentioned prior to the target sentence, it was the only color mentioned in the story, and each experimental story had a different color word. The target sentence was always followed by a final sentence.

The filler stories were of comparable lengths and topics to the experimental stories and served to obscure the manipulation. Sixteen of the filler stories contained one or more color words, and 36 did not. Each story was combined with a probe word. For the experimental items, the probe word corresponded to the color mentioned in the target sentence. For 18 of the filler stories, the probe word also was a word mentioned in the story (9 nouns, 9 adjectives), and for the remaining 34 filler stories, the probe word had not been mentioned in the story (10 nouns, 14 color words, 10 other adjectives). For each story, a simple comprehension question was constructed, with half of the comprehension questions requiring a "yes" response and the other half requiring a "no" response.

Design and procedure. Each participant read all 24 experimental items intermixed with all 52 filler items. The 24 experimental items were assigned to four sets, the 48 participants were assigned to four groups, and the assignment of versions to sets and groups was according to a $4 \times 4 \times 4$ Latin square. The items were presented in two different orders. Of each group, 6 participants read the items in the first order, and the remaining 6 participants read them in the second order. Both item orders were such that each of the 24 experimental color words was first mentioned in an experimental item.

The materials were displayed on a 15-in. (38.1-cm) monitor, using the Psyscope software (cf. Cohen, MacWhinney, Flatt, & Provost, 1993). Texts were presented in uppercase and lowercase letters; probe words and comprehension questions were presented in uppercase letters only. Text

presentation was sentence by sentence, self-paced by the participant pressing the space bar. Pressing the space bar after reading the target sentence of an item elicited the presentation of a fixation star in the center of the monitor, which was replaced by the probe word after 500 ms. Participants decided whether the word had been mentioned in the story by pressing the appropriate key (. and *x* keys, marked with *y* and *n*, respectively). Participants' responses elicited the presentation of the final sentence of the story, after which they read the comprehension question. Participants responded to the question by pressing the *y* or *n* key. The experimental session lasted approximately 60 min.

Results and Discussion

Analyses were performed on response latencies in the probe-recognition task of experimental trials. Only latencies of correct responses were analyzed, and, of these, only those were analyzed that deviated less than two standard deviations from the participant mean in the corresponding condition (96.7% of correct responses satisfied this condition). Latencies were submitted to two analyses of variance (ANOVAs), one based on participant variability (F_1), and one based on item variability (F_2). Corresponding to the Latin square assignment of versions to participant groups and item sets, group was included as a between-subjects factor in the initial participant analysis, and set was included as a between-items factor in the item analysis. Because participant group did not interact significantly with the variables of interest, the participant analysis was a 2 (presence) $\times$ 2 (negation) ANOVA, with both factors as within-subject variables. The item analysis, in contrast, was a 2 (presence) $\times$ 2 (negation) $\times$ 4 (set) ANOVA, with presence and negation as within-item variables in both analyses. Because they lack theoretical interest, the effects of set are not reported. The means of the latencies in the four experimental conditions, the standard errors, and the percentages of errors are displayed in Table 1.

Participants responded more slowly to probe words that were mentioned within a negative phrase than to probe words that were mentioned within an affirmative phrase, $F_1(1, 47) = 6.24$, $p < .05$; $F_2(1, 20) = 4.47$, $p < .05$. The presence–absence effect was not significant ($F_1 < 1.00$; $F_2 < 1.00$), and the interaction was marginal for the participant analysis and not significant for the item analysis, $F_1(1, 47) = 3.24$, $p < .08$; $F_2(1, 20) = 1.89$, $p = .18$.

The results suggest that 500 ms after an individual reads a sentence, a concept's accessibility depends on the linguistic structure of the phrase it was mentioned in. Concepts mentioned in a negative phrase were less accessible than concepts mentioned in an affirmative phrase. This finding supports the hypothesis that participants construct a linguistic representation of the sentence in which negation functions as an accessibility-reducing mechanism. Whether this representation is indeed a propositional representation of the sentence meaning or another kind of linguistic representation in which negation is explicitly represented (e.g., a surface-level representation) is unclear. The results do not indicate that participants also had available a situation model of the aspects described in the target sentence. Experiment 2 was conducted to find out whether this pattern would hold 1,500 ms after individuals read the sentence.

Experiment 2

Method

Participants. Forty-eight students at Florida State University participated in the experiment for course credit.

Materials. The materials were the same as in Experiment 1.

Design and procedure. The design and procedure were the same as in Experiment 1, with the one exception that for all stories the fixation star was presented for 1,500 ms before being replaced by the probe word.

Results and Discussion

Analyses were performed as in Experiment 1 (group was not included in the analyses reported here because it did not significantly interact with the factors of interest). The data from 1 participant were removed, because in one condition they were more than two standard deviations slower than the average reaction time for that condition (removal of these data did not affect the statistical pattern). Outlier elimination reduced the data set by 3.9%. The means, the standard errors, and the error percentages are displayed in Table 1. Participants responded significantly more quickly to present colors than they did to absent colors, $F_1(1, 46) = 6.67$, $p < .05$; $F_2(1, 20) = 9.25$, $p < .01$. Whether the color word had been mentioned in a negated phrase did not influence the response times, $F_1(1, 46) = 1.63$, $p > .20$; $F_2 < 1.00$, and there also was no interaction between the two variables (both Fs < 1.00).

The results of this experiment suggest that 1,500 ms after reading a sentence, participants based their responses on a situation model in which present but not absent properties are represented and therefore highly accessible. Participants responded signifi-

Table 1
Mean Latencies and Standard Errors of Correct Responses (in ms) and Error Percentages in the Probe Recognition Task of Experiment 1 (500-ms delay) and Experiment 2 (1,500-ms delay)

	500 ms						1,500 ms					
	Affirmative			Negative			Affirmative			Negative		
Condition	*M*	*SE*	% Err	*M*	*SE*	% Err	*M*	*SE*	% Err	*M*	*SE*	% Err
Present	727.0	34.9	2.1	776.0	36.3	2.4	770.0	39.0	1.3	787.0	37.5	1.0
Absent	751.0	35.0	2.1	763.0	37.6	0.3	807.0	41.9	2.4	827.0	42.4	1.0

Note. Err = error.

cantly faster to a probe word when the corresponding color was present in the described situation than when it was absent. The fact that the accessibility of the color terms was not influenced by the polarity of the phrases they were mentioned in suggests that a linguistic representation of the text did not play a significant role in the participants' response processes.

To directly compare the results at the two different delays (500 ms and 1,500 ms), we conducted a combined analysis of the data from Experiments 1 and 2. Delay was treated as a between-subjects and within-item variable. Group was excluded from the analyses because it did not interact with the variables of interest. The analysis produced a significant main effect of presence—participants responded significantly faster to the probe words when the corresponding color was present in the described situation than when it was absent from it, $F_1(1, 93) = 4.28$, $p < .05$; $F_2(1, 20) = 4.68$, $p < .05$. There was also a main effect of negation, which, however, was only significant in the participant analysis, $F_1(1, 93) = 6.68$, $p < .05$; $F_2(1, 20) = 2.58$, $p = .12$. The main effect of delay was significant in the item analysis but not in the participant analysis, $F_1 < 1.00$; $F_2(1, 20) = 26.04$, $p < .01$. The two-way interaction of delay and presence was marginal, $F_1(1, 93) = 2.36$, $p = .13$; $F_2(1, 20) = 3.19$, $p = .09$, and neither of the two remaining two-way interactions (Delay × Negation and Presence × Negation) was significant (all Fs <1.00). The three-way interaction of delay, presence, and negation was also not significant, $F_1(1, 93) = 1.14$, $p = .29$; $F_2(1, 20) = 1.16$, $p = .30$.

The fact that the combined analysis did not produce a significant three-way interaction of delay, presence, and negation is not in accordance with the very clear-cut interpretation that was presented up to now. According to this interpretation of the results, 500 ms after reading a sentence, comprehenders only have available a propositional representation of the sentence, in which negation reduces accessibility. However, 1,500 ms after reading a sentence, comprehenders are proposed to have finished constructing a situation model, and, as a result, their propositional representation has become irrelevant. Thus, 500 ms after reading a sentence, participants' responses to the probe-recognition task should be influenced only by whether the probe word was mentioned in a negated phrase but not by whether the corresponding color was present in the described situation. In contrast, 1,500 ms after reading a sentence, participants' responses should only be influenced by the content of the described situation, not by the polarity of the sentence (affirmative/negative). Although the results of the individual analyses of the two experiments seem to more or less correspond to these predictions, the combined analysis did not produce a significant interaction of delay, negation, and presence. In the General Discussion, we consider three explanations for this pattern of results.

General Discussion

Our goal was to investigate the influences of negation and situational presence on the accessibility of text information. The influences of these often correlated variables were disentangled in two ways. First, we varied the two variables orthogonally to each other within participants and texts. Second, we varied the delay between presenting the relevant text information and measuring its accessibility. In two experiments, participants read narratives containing a target sentence in which a color term was mentioned either within the scope of an explicit negative or not, and with the described situation being such that the corresponding color was either present or not. The accessibility of the color term was measured either 500 ms or 1,500 ms after participants read the target sentence.

The results of the two experiments are rather clear-cut. After a 500-ms delay, the color term's accessibility depended mainly on the linguistic structure of the sentence. Participants responded significantly faster if the color term had been mentioned in an affirmative phrase compared with when it had been mentioned in a negative phrase. After a 1,500-ms delay, however, the color term's accessibility was influenced only by the content of the described situation. Participants responded faster to a color probe when the corresponding color was present in the described situation compared with when it was absent from the situation. These findings are consistent with the hypothesis that participants construct two different kinds of representations, a linguistic representation of the text, in which negation functions as an accessibility-reducing mechanism, and a situation model, in which only those entities and properties that are present in the described situation are represented. However, a closer analysis of the results suggests that this explanation is not quite borne out by the data. Specifically, there was no significant three-way interaction involving negation, presence, and delay. We consider an alternative explanation for the data next.

On closer examination of the materials, it is clear that there is an additional difference among the four versions that is relevant to the issue of negation but was not taken into consideration before. Specifically, whereas the syntactic structure of the embedding clause in the *was relieved* versions is affirmative, the one in the *wished* versions is implicitly negative (see Brütsch, 1986; Jacobs, 1991). Thus, in addition to being different with respect to the number of explicit negatives, the versions also differ with respect to the number of implicit negatives they contain. The affirmative-absent and the negative-present conditions contain an implicit negative, whereas the affirmative-present and the negative-absent conditions do not. Overall, the negative-present condition (*wished–not pink*) therefore contains two negations (one explicit, one implicit), the two absent conditions each contain only one negation, and the affirmative-present condition (*relieved–pink*) does not contain any negation at all. There is evidence that sentences containing an implicit negative are more difficult to process than affirmative sentences (e.g., Chase & Clark, 1971; Clark & Chase, 1974; Just & Clark, 1973) and that sentences become more and more difficult to process the more negations (explicit or implicit) they contain (e.g., Sherman, 1976). Thus, it may be presumed that the target sentences in the four versions constitute a hierarchy with respect to processing complexity. The affirmative-present sentences are the easiest, the negative-present sentences are the hardest, and the affirmative-absent and negative-absent sentences fall somewhere in between.

How do these considerations relate to our findings? It is possible that the 500-ms interval did not allow participants to complete all the necessary steps in constructing the final representation for the target sentences in all of the versions. This could have led to slower response times in the subsequent probe-recognition task (relative to the affirmative-present sentences) for two reasons or a

combination of the two: (a) The recognition judgment was not based on a completed representation and thus received no priming, or (b) because they were still engaged in constructing the final representation, participants had to make a time-consuming mental switch to the recognition task. As a consequence, the negation effect (and also the lack of a presence effect) in Experiment 1 may be solely due to differences in the complexity of the target sentences. The particular pattern of the response times in Experiment 1 fits this interpretation of the results. The negation effect is primarily due to the items in the present condition; affirmative present versus negative present: $t_1(47) = 3.84$, $p < .01$; $F_2(1, 20) = 5.78$, $p < .05$; affirmative absent versus negative absent: $t < 1.00$, $p > .50$; $F_2 < 1.00$. The negative-present sentences contain two negatives, whereas the affirmative-present sentences contain zero. Analogously, the lack of a presence effect is primarily due to the negative sentences, where the present sentence contains two negations and the absent sentence only one; affirmative present versus affirmative absent: $t_1(47) = 1.50$, $p = .14$; $F_2(1, 20) = 2.00$, $p = .17$; negative present versus negative absent: $t < 1.00$, $p > .50$; $F_2 < 1.00$.

In an attempt to obtain independent evidence regarding this claim, we analyzed the reading times of the target sentences. Because the target sentences differed not only with respect to the complexity of the sentence meaning but also with respect to the number of syllables, we calculated for each participant a linear regression with the number of syllables as predictor and the raw reading time as predicted variable. The unstandardized residuals were then submitted to a 2 (delay) × 2 (presence) × 2 (negation) × 4 (group/set) ANOVA with presence and negation constituting within-subject and within-item variables, delay constituting a between-subjects and within-item variable, and set and group constituting the counterbalancing Latin square variables. As before, we do not report the effects of group and set because of lack of theoretical relevance. As expected, delay did not have any significant influence on the reading times of the target sentences, and we therefore conducted a second analysis in which we collapsed across the two levels of delay. The means of the residuals in the four conditions were −135, 106, 73, and 67 for the affirmative-present, the negative-present, the affirmative-absent, and the negative-absent condition, respectively. The analysis produced a significant main effect of negation, $F_1(1, 91) = 7.33$, $p < .05$; $F_2(1, 20) = 4.49$, $p < .05$, and a significant interaction of negation and presence, $F_1(1, 91) = 7.64$, $p < .01$; $F_2(1, 20) = 4.97$, $p < .05$. The main effect of presence was not significant in the item analysis, but a trend emerged in the participant analysis, $F_1(1, 91) = 3.68$, $p = .06$; $F_2(1, 20) = 1.90$, $p = .18$. Planned comparisons revealed a significant negation effect for the present sentences, $F_1(1, 91) = 13.35$, $p < .01$; $F_2(1, 20) = 9.53$, $p < .01$, and a significant presence effect for the affirmative sentences, $F_1(1, 91) = 9.71$, $p < .01$; $F_2(1, 20) = 6.21$, $p < .05$. There was no negation effect for the absent probes nor a presence effect for the negated probes (all Fs < 1.00). (A similar statistical pattern was observed when the raw reading times were used as dependent variable instead of the residuals.) The particular pattern of the reading times in the four versions as well as the statistical results are remarkably similar to the probe-recognition data obtained with the 500-ms interval. This similarity supports the view that the probe recognition data obtained at 500 ms reflect differences in the complexity among the four versions of the target sentences, as was proposed above.

It should be noted that the results of these reading time analyses not only are relevant to the general hypothesis that the results obtained with the 500-ms interval reflect spill-over effects from the processing of the target sentences but are also informative with respect to the more specific hypotheses regarding the particular complexity differences among the four versions of the target sentences. The results of the probe-recognition data in Experiment 1 were a little ambiguous with respect to the question of whether the negation effect interacted with the presence of the corresponding color in the described situation. A reader who interprets the results according to the hard statistical facts (a significant negation effect and a not significant interaction) would probably propose a simple spill-over account, according to which the versions with an explicit negation are harder to process than those without an explicit negation. The most intuitive reason for why this might be the case is that a sentence with an explicit negation always contains at least one more word than the corresponding sentence without an explicit negation. Another reason that comes to mind is pragmatic in nature.[1] It is well known that sentences with an explicit negation are typically used to deny incorrect presuppositions (Givón, 1978). If this pragmatic constraint is violated, negative sentences are particularly hard to process, presumably because comprehenders need extra time to infer these presuppositions (Glenberg, Robertson, Jansen, & Johnson-Glenberg, 1999; Wason, 1965). However, in contrast to the predictions of these simple spill-over accounts, the negation effect interacted significantly with the presence of the corresponding color in the reading time analyses of the target sentences. Thus, explicitly negative versions were not generally harder to process than the versions without an explicit negation, but only in the condition in which the color was present in the described situation. The pragmatic spill-over account is implausible for the present data for another reason. A closer look at the negative sentences used in the present experiments reveals that (if at all) only one of the two explicitly negative versions invites an inferencing of the proposed type. In other words, it might be argued that *Sam was relieved that Laura was not wearing her pink dress* requires the inference *Sam expected Laura to wear her pink dress*, but the same does not hold for the negative present version, in which Sam wished that Laura was not wearing her pink dress. In contrast to these specific considerations, latencies were not particulary long in the negative-absent condition, either in the probe-recognition data of Experiment 1 or in the reading time analyses. Thus, in our view, the combined results are more consistent with the view that the processing complexity of the target sentences is determined by the total number of explicit and implicit negations that are present in the sentences. According to this proposal, the affirmative-present condition should be the easiest, the negative-present condition should be the hardest, and the other two conditions should be somewhere in between. The pattern of the means of the probe-recognition data in Experiment 1 as well as the pattern of the means of the reading time analyses for the target sentences correspond exactly to this prediction. The fact that the Negation ×

[1] We thank Art Glenberg for suggesting this explanation.

Presence interaction proved significant in the reading time analyses provides further evidence for the proposed hierarchy of complexity.

The null result of negation in Experiment 2 seems particularly relevant to the overall interpretation of the results. We therefore conducted a post hoc power analysis with the program *G*Power* (Erdfelder, Faul, & Buchner, 1996) to find out whether our design in Experiment 2 had enough power to detect an effect of negation. As already discussed, the significant main effect of negation observed in Experiment 1 was primarily due to the differences in the two present conditions. The effect size of this particular contrast was 0.55 (i.e., a large effect, according to Cohen's, 1977, effect size conventions). The power to detect an effect of this size in the two present conditions of Experiment 2 was determined to be 0.98, critical $t(46) = 1.68$; observed $t(46) = 0.80$, $p > .40$. The power to detect a medium-sized effect ($f = 0.25$; cf. Cohen, 1977), however, was determined to be 0.52. Thus, we cannot completely rule out that there was a small or medium-sized effect of negation in the two present conditions of Experiment 2. What we can rule out, however, is that there was an effect of negation that is comparable in size to the one observed in Experiment 1.

Three Accounts

We now consider three accounts for the entire set of results: a pure amodal propositional account, a revised multilevel account, and a perceptual-symbol account. All three accounts are based on the assumption that the results obtained with the 500-ms delay reflect spill-over effects from the processing of the target sentences, whereas the results obtained with the 1,500-ms delay reflect differences in the accessibility of the color probes. However, they differ in all other respects.

The pure amodal propositional view has a natural way of accounting for the complexity differences among the versions: For each negation (explicit or implicit), a negation operation is applied, and the current representation is placed within its scope. However, this account has difficulty accounting for the presence effect in Experiment 2. The fact that the presence of an entity in the described situation affects its accessibility is not something that amodal propositional theories predict or can explain in a straightforward way. On the other hand, a revised multilevel account can explain this pattern. According to this account, comprehenders construct two different kinds of meaning representations, a propositional representation and a situation model. Constructing the propositional representation becomes more and more difficult depending on how many negations are contained in the corresponding sentence, which explains the pattern of the results at the 500-ms delay. At the 1,500-ms delay, comprehenders have finished constructing their propositional representation and now have available a model of the described situation. Accordingly, the number of negations that are contained in the different versions of the target sentences has become irrelevant, but the content of the described situation affects the accessibility of the color probes. It should be noted that this interpretation of the results leaves open whether negation reduces the accessibility of information in its scope at the propositional level of representation.

Third, there is a perceptual-symbol account that can explain the findings. In cognitive psychology and in language comprehension research in particular, there is mounting evidence that comprehenders construct perceptual simulations of the referent situation (Dahan & Tanenhaus, 2002; Glenberg & Kaschak, 2002; Pecher, Zeelenberg, & Barsalou, in press; Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2002; Zwaan & Yaxley, in press). Proponents of the perceptual view argue that the perceptual simulation is the only meaning-related representation that is constructed in comprehension (Barsalou, 1999). Obviously, the presence effect fits in nicely with the notion of a perceptual simulation. Something that is part of the perceptual simulation of the situation should be more accessible than something that is not. Thus, in this sense, the perceptual view has more explanatory power than the amodal view. But how about the negation effect? As noted earlier, there is a rather straightforward amodal propositional account for negation effects. Information that is within the scope of a negation operator is less accessible than information that is not. However, there is also a perceptual account. This account trades on the hypothesis that a negation is a cue to the comprehender to do two things: First, construct a mental simulation of the embedded situation, and, second, focus attention away from this representation toward the representation of the actual situation (Fauconnier, 1985; Langacker, 1991). Thus, in the affirmative-present condition (*relieved–pink*), the comprehender arrives at the final representation in only one step. A pink dress is represented right away. In the affirmative-absent condition (*wished–pink*), in contrast, two steps are required. First, the comprehender simulates what was wished by the protagonist but was not the case—namely, a pink dress. In a second step, the comprehender then directs attention away from this simulation and instead focuses on a simulation of a dress that is not pink. The negative-absent condition (*relieved–not pink*) requires the equivalent two steps, from pink to not pink. Finally, the negative-present condition (*wished–not pink*) is the most complex, as it requires three steps, from pink to not pink to pink again.

The hypothesis that negated information is first being simulated perceptually is currently being tested directly in our laboratory. In three experiments, we applied the paradigm that was developed by Zwaan et al. (2002) for testing the perceptual-simulations view with affirmative sentences to negative sentences (Kaup, Yaxley, Madden, & Zwaan, 2002). In Zwaan et al.'s study, participants were presented with sentences such as *The ranger saw an eagle in the sky* or *The ranger saw an eagle in the nest* and afterward 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 . . . *in the sky*; folded wings for . . . *in the nest*) or not (folded wings for . . . *in the sky*; outstretched wings for . . . *in the nest*). Zwaan et al. 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 indicates that comprehenders routinely 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 triggers perceptual simulations of the referent situations. What can be predicted about negated sentences in this paradigm? If it is true that negation is a cue to the comprehender to construct a perceptual

simulation of the negated state of affairs, then the negated sentences should yield similar match/mismatch effects to the affirmative sentences. Hence, if comprehending a sentence such as *There was no eagle in the sky* initially requires a simulation of an eagle in the sky, then this should be reflected in the response latencies elicited by pictures of an eagle with outstretched or folded wings, respectively. In accordance with these predictions, latencies were shorter if the picture matched the implied shape of the object in the situation that was being negated (i.e., outstretched wings for *in the sky* and folded wings for *in the nest*) than when there was a mismatch (i.e., folded wings for *in the sky* and outstreched wings for *in the nest*). Thus, the results of these three experiments are consistent with the idea that comprehenders first simulate the negated state of affairs when comprehending a negative sentence. It should be noted that the perceptual negation account that was outlined above does not generally predict the same simulation effects for negative and affirmative sentences. Only at first should negative sentences exhibit the same simulation effects as the corresponding affirmative sentences. Once comprehenders start shifting their attention away from the negated state of affairs and onto the simulation of the actual state of affairs, the observed simulation effects should be quite different for negative and affirmative sentences. For instance, it could be expected that the match/mismatch effect decreases with an increasing delay between reading the sentence and seeing the picture for negative sentences but increases or stays the same for affirmative sentences. Future studies are necessary to test these predictions that concern the second step of the proposed two-step account, namely the shifting away of attention from the negated state of affairs to the actual state of affairs.

Conclusion

The results of the two experiments speak against a pure amodal propositional account, according to which the only meaning-related representation that is constructed in language comprehension is a propositional text base. It is possible, however, to interpret our findings as being consistent with a multilevel theory of language comprehension (textbase-situation model). The findings are consistent with earlier findings showing an early effect of the textbase and a later effect of the situation model (Till, Mross, & Kintsch, 1988). However, we also considered a perceptual explanation, according to which there is no textbase level. In the theoretical domain, Occam's razor tells us such an explanation is preferable because it posits only one type of mental representation (in addition to a representation of the surface structure), whereas the multilevel view posits two (in addition to the surface structure). In the empirical domain, however, there is no complete evidence as yet for our perceptual notion of negation (i.e., construction followed by an attentional shift), although there is mounting evidence for the perceptual framework in general (Glenberg & Kaschak, 2002; Kaup, Kelter, Habel, & Clauser, 1999; Kellenbach, Wijers, & Mulder, 2000; Pecher et al., in press; Solomon & Barsalou, 2001; Stanfield & Zwaan, 2001; Zwaan et al., 2002). As mentioned earlier, work is under way in our lab to collect relevant data. It seems that being able to account for negation is a critical test for any theory of language comprehension, but for perceptual theories in particular, because negation cannot be represented explicitly in a perceptual representation.

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Appendix

Sample Story for Experiments 1 and 2

Segment type	Segment example
Title	Tenth Birthday
Setting	Susan was lying in bed trying to fall asleep. Tomorrow would be her tenth birthday. She always had problems falling asleep the night before her birthdays. She already knew that she would be getting a new bike for her birthday. She had overheard a conversation between her parents the other night. This morning Susan had gone into the garage and had looked at the new bike. Now she was trying to imagine what her friends would say about her new bike.
Target sentence	Susan thought that they would like the bike,
Aff/present	and she was glad that the bike had a blue frame.
Neg/present	she only wished that the bike didn't have a blue frame.
Aff/absent	she only wished that the bike had a blue frame.
Neg/absent	and she was glad that the bike didn't have a blue frame.
Probe word	BLUE
Final sentence	At midnight Susan finally fell asleep.
Question	WAS SUSAN THINKING ABOUT HER PRESENT?

Note. Each participant was presented with only one of the versions per text. Aff = affirmative; Neg = negative.

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