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Processing Presupposed Content

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Abstract

This paper presents three experimental studies investigating the processing of presupposed content. The first two experiments employ the German additive particle *auch* 'too', and the third uses English *also*. In experiment 1, participants were given a questionnaire containing biclausal, ambiguous sentences containing *auch*. The presupposition introduced by *auch* was only satisfied on one of the two readings, which corresponded to a syntactically dispreferred parse of the sentence. The prospect of having the *auch* presupposition satisfied made participants choose this syntactically dispreferred reading more frequently than in a control condition. Experiment 2 used the self-paced reading paradigm and compared the reading times on clauses containing *auch*, which differed in whether the presupposition of *auch* was satisfied or not. Participants read the clause more slowly when the presupposition was not satisfied. Experiment 3 followed up a number of issues that arose from experiment 2 and confirmed the results found there. These studies show that presuppositions play an important role in online sentence comprehension and affect the choice of syntactic analysis. Some theoretical implications of these findings for the semantic analysis of *auch*/*also* and dynamic accounts of presuppositions as well as for theories of semantic processing are discussed.

1 INTRODUCTION

Presuppositions have been an important topic in both the philosophy of language and in linguistic semantics and pragmatics, but only more recently have they been investigated with psycholinguistic methods. However, a lot can be gained from such investigations, both with respect to theoretical issues in presupposition theory and with respect to our understanding of semantic processing. In the following, I present three experimental studies, two of which employ the German additive particle *auch* 'too', while the last one uses English *also*. The results of these studies reveal processing effects of presuppositions. These support analyses of additive particles that account for the fact that their presuppositions cannot easily be accommodated. They furthermore suggest that presuppositions play a role in online sentence processing, that is that they can affect the way incoming linguistic input is analysed by the parser. In theoretical terms, they can be seen as constraining the

possible analyses of presuppositional phenomena in general. I argue that the specific results presented here suggest that the processor carries out something like updates of the representations of contexts (in the sense of Dynamic Semantics or Discourse Representation Theory, DRT) below the sentence level in actual processing, namely, at the level of noun phrases. Assuming that the processor does this by using the available grammatical mechanisms, this, in turn, requires that our theory of semantic interpretation in context allows for updates at such a lower level. In addition to these theoretical conclusions, some questions arising for a theory of semantic processing are also discussed.

The paper is organized as follows: in section 2, I provide some background on the main issues relevant to the experiments, including my theoretical assumptions about presuppositions and a few remarks about existing work on semantic processing. Section 3 presents the three experimental studies that were carried out. Section 4 discusses implications of the experimental results for the analysis of additive particles and for issues relating semantic theory and semantic processing, as well as some perspectives on future research. Section 5 concludes the paper.

2 BACKGROUND

One might start out the enterprise of investigating presuppositions in processing by wondering about how we can capture their effects in online sentence comprehension studies at all. After all, they are most commonly thought of as crucially relating to the context, and in the experimental settings typically used in psycholinguistic work, there is no realistic context. So, it is at least possible that participants in experiments more or less ignore such context-related information. This would be especially likely if presuppositions were dealt with in very late pragmatic processes that are more like conscious reasoning. If, on the other hand, the processor automatically makes use of presupposed content, we would expect participants to be unable to ignore it. The question then becomes in what ways presuppositions affect the parsing of incoming strings of linguistic expressions, and how quickly their content is accessible to the parser: does it occur online, that is, during the process of parsing the linguistic input or is it part of later, more general inferencing processes that may take place after the parser has decided on a structure and an interpretation of the linguistic input. It is generally assumed that interpretation proceeds incrementally, but the details of how incremental interpretation of specific semantic phenomena takes

place are only partially understood. Looking at processing effects of presuppositions, which have been studied in depth in formal semantics and pragmatics, can provide us insights into how and when a specific aspect of meaning enters the picture in sentence comprehension processes. A further related point of interest is whether presuppositions interact with other factors known to be relevant in parsing, and if so in what ways.

From a theoretical viewpoint, we are, of course, especially interested in what implications experimental results might have for semantic and pragmatic theory. First of all, we should consider how our semantic analyses of the specific presupposition triggers relate to them. The relevant issues for *auch* and *also* will be introduced in section 3, in connection with the experimental design. Furthermore, we want to relate them to the bigger picture of possible semantic frameworks for presupposition theory. In connection with this it is interesting to note that most of these share a procedural view of some sort which determines how presupposed content is integrated with contextual information (although typically they do not make any explicit claims about actual processing). The family of approaches to semantic theory going under the labels of Dynamic Semantics (Heim 1982; Heim 1983a,b) or DRT (Kamp 1981; Kamp & Reyle 1993), which formalize earlier insights by Stalnaker and Karttunen (Karttunen 1973, 1974; Stalnaker 1973, 1974), has been particularly important in presupposition theory (van der Sandt 1988, 1992; Geurts 1999; Beaver 2001). For concreteness and simplicity, I will frame the discussion in this paper in terms of one specific proposal in this family, namely Heim's original File Change Semantics. However, it should be clear that the results could just as well be described in other dynamic systems, for example, DRT.[1]

In approaches to presupposition theory in the tradition of Stalnaker and Karttunen, presuppositions are assumed to have two crucial properties. First, they are something that is taken for granted by the discourse participants. Secondly, they behave differently from asserted content in most embedded contexts. This is at the heart of the *projection problem* (for an overview, see Beaver 1997; von Fintel 2004). In File Change Semantics, which can be viewed as a formal

[1] DRT is usually assumed to be equivalent to File Change Semantics in most respects. One difference is that the former makes reference to formal properties of Discourse Representation Structures (DRSs). File Change Semantics is more neutral in that it does not formulate its generalizations in terms of any specific representation, but rather at the level of content. This is not incompatible with talking about mental representations in connection with processing, however, which can be characterized as having a particular content. It simply does not say anything about the format of those representations.

implementation of the accounts for presuppositional phenomena by Stalnaker and Karttunen, being taken for granted is modelled by the *common ground*, which is the set of worlds in which all of the beliefs that the discourse participants knowingly share are true. A sentence can only be felicitously uttered when the presuppositions that come with uttering the sentence are entailed by the common ground. The behaviour of presuppositions in embedded contexts is accounted for by the way that the common ground is updated when a new utterance is made in the discourse. Under certain circumstances, presupposition failure can be remedied by a process of accommodation (Lewis 1979), in which the common ground is adjusted in such a way that it does entail the presupposition at issue prior to the update.

File Change Semantics represents the meanings of sentences as context change potentials. More concretely, sentence meanings are understood as functions from contexts to contexts (where contexts are modelled either as sets of worlds or as sets of pairs of worlds and assignment functions). One of the crucial issues in this type of theory is where or when context updates take place, and this is where the procedural viewpoint becomes relevant: the issue of when the adjustments to the context are made is determined by the procedural steps that the theory assumes. Quite frequently the discussion in the literature focuses on the sentence or clause level as the locus of updates, which seems intuitively plausible. However, in the full version of Heim's system, which includes assignment functions, updates also take place at the level of noun phrases (which are viewed as denoting atomic propositions). Furthermore, in order to account for certain facts concerning the behaviour of presuppositions in embedded contexts, Heim (1983a) introduces the notions of local and global accommodation. As I will discuss in some detail below, the issue of where updates take place is crucial for semantic processing viewed from the perspective of File Change Semantics: if the processor is to make use of compositional semantic information, the way in which it can be used depends on the time at which it has access to it.

Before turning to the discussion of the experiments, let me briefly review some existing work on presuppositions in processing. Much related work focuses on the presupposition of the definite article and follows the approach taken in the seminal study of Crain & Steedman (1985).[2] Looking at locally ambiguous sentences like the one in (1),

[2] But recent work is becoming more diverse in terms of the presupposition triggers covered. See, for example, Chambers & Juan (2005) on *again* and for new work on pragmatic processing more generally the volume edited by Noveck & Sperber (2004).

their experiment 2 showed that varying the discourse context [as in (2)] affects the way that the sentence is parsed.

(1) The psychologist told the wife that he was having trouble with . . .
  a. . . . her husband.
  b. . . . to leave her husband.

(2) a. Complement Inducing Context
  A psychologist was counseling a married couple. One member of the pair was fighting with him but the other one was nice to him.
  b. Relative Inducing Context
  A psychologist was counseling two married couples. One of the couples was fighting with him but the other one was nice to him.

In (1a) the *that* clause is interpreted as the complement of *told*, while in (1b), it is a relative clause modifying *wife*. The latter reading is much harder to see due to a typical garden-path effect (especially out of context). The preceding contexts were varied in introducing either one or two couples, the idea being that if two couples are introduced, the definite description consisting of the noun only (*the wife*) cannot refer successfully, while the complex description consisting of the noun and the following *that* clause analysed as a relative clause does have a unique referent. The sentences were judged to be ungrammatical 54% of the time in a grammaticality judgment task when (1a) was presented in the relative inducing context, but they were judged to be grammatical 78% (1a) and 88% (1b) of the time when the contexts matched the target sentence. Crucially, even the garden-path in (1b) was ameliorated by putting it in a matching context. This finding motivated Crain and Steedman to propose a principle of parsimony, which guides the selection between different syntactic parses in their parallel parsing architecture, so that the reading carrying the fewest unsatisfied presuppositions will be the preferred one. Similar designs are used in more recent work by van Berkum and colleagues (van Berkum *et al*. 1999, 2003), which shows that there are ERP effects related to whether the definite description can refer successfully or not. These studies focus on definite descriptions and show effects of presuppositions relative to preceding discourse. The studies presented here aim to broaden the range of triggers being studied and to look at effects of presuppositions in relation to material within the same sentence. The experimental techniques used here contribute a new type of evidence to presupposition theory, where many hotly debated issues involve subtle intuitions. Furthermore, an attempt is made to integrate the experimental results into the theoretical discussion, in order to contribute to a theory of semantic processing informed by linguistic semantics.

3 EXPERIMENTAL STUDIES ON *AUCH* AND *ALSO*

How should we go about testing the potential effects of presuppositions in sentence processing? One of the standard techniques in psycholinguistics is to compare a normal or unproblematic form to a somehow deviant (or temporarily deviant seeming) form. This basic idea is applied to presuppositions in the studies below in two ways: first, participants were shown ambiguous sentences containing *auch*, where one reading of the sentence satisfied the presupposition introduced by *auch*, whereas the other did not. The task, then, was to choose a paraphrase corresponding to the participants' understanding of the sentence. The second approach was to show unambiguous sentences with *auch* (experiment 2) and *also* (experiment 3) that varied in whether the presupposition was satisfied or not. These studies employed the self-paced reading method, and participants simply had to read the sentences region by region. In experiment 2, they also had to answer simple questions about the sentences.

Let us now turn to the question of what the presupposition of *also* is, and how it relates to the experimental design. It is well known that the presuppositions introduced by many triggers can easily be accommodated. It certainly is a possibility to be considered that in an experimental setting participants are willing to accommodate just about any content, since the situation they are in is obviously artificial. Just compare this situation to reading an example sentence in a linguistics article. It might very well contain, say, a definite description. There is nothing odd about reading such a sentence, even if it is completely unclear and left open whether the relevant presuppositions are satisfied or not. The danger for an experimental inquiry into presuppositions in processing might be that their effects cannot be measured at all, at least to the extent to which they can be accommodated without a problem.[3] There are, however, a few presupposition triggers that have been argued to either strongly resist accommodation or be unaccommodable altogether (Beaver and Zeevat forthcoming). One case in point is additive particles like *too* and *also*.

According to the early analysis of *too* by Karttunen & Peters (1979), this type of additive particle introduces an existential presupposition, requiring that there is another individual that has the property attributed to the focus of the sentence with *too* (e.g. 'BILL likes Mary too' would presuppose that there is someone other than Bill who likes

[3] A related question of great interest is to what extent accommodation has measurable effects. Although this is just as important, I would not pursue this question here.

Mary). However, Kripke has argued that this type of analysis is inadequate, based on examples like the one in (3a) (from Kripke 1991).

(3) a. JOHN is having dinner in New York tonight too.
b. Did you know that Bill is having dinner in New York tonight?

In an out of the blue context, the sentence in (3a) is very odd, presumably due to a presupposition failure that cannot be remedied by accommodation. This is unexpected on the existential analysis, since in just about any context, it will be uncontroversial that there are many people having dinner in New York tonight. But it is clear that the utterance of (3a) is only felicitous when there is some individual salient in the discourse that has the relevant property, for example, in the context of (3b). One way to capture this property is by assuming that *too* is anaphoric, much like a pronoun, and that its presupposition can only be satisfied if there is an antecedent in the discourse context (Heim 1992; van der Sandt & Geurts 2001). It is exactly this property that makes *also* a useful presupposition trigger for the present purposes. If these additive particles strongly resist accommodation, we can have good hopes of finding processing effects when their presuppositions are not satisfied. The flip side of this is that strong processing effects of presupposition failure with these triggers support the idea that they are impossible (or at least very hard) to accommodate and analyses that account for this property, such as the anaphoric accounts mentioned above.

In connection with this, it is also worth noting the work by Spenader (2002), who provides solid empirical evidence that the presupposition of *too* is hardly ever accommodated. In a corpus study of the London-Lund Corpus, she finds that *too* lacks an antecedent only 4% of the time, whereas many other presupposition triggers (e.g. definite descriptions and factives) lack an antecedent much more often (40% and 80% of the time, respectively) and are apparently easily accommodated in such situations.

In summary, *too* (as well as *also* and its German counterpart *auch*) lends itself to experimental investigation. On the one hand, we have more control over whether presupposition failure takes place or not, since it is quite clear intuitively that sentences like (3b) are infelicitous without the right kind of supporting context. And on the other hand, we can hope to find a new form of empirical support for accounts that have an explanation for the difficulty of accommodation, if we find strong effects of presupposition failure.

3.1 *Questionnaire study on auch*

3.1.1 *Methods and materials* The basic strategy for the experimental items for the first study was to construct biclausal, ambiguous sentences consisting of a relative clause and a main clause. One of the readings was preferred based on well-known syntactic parsing preferences. The other reading was the one that satisfied the presupposition of *also*, which appeared in the second clause. An example is given in (4). *N* and *A* stand for nominative and accusative, respectively.

(4) Die Frau, die das Mädchen sah, hatte
The woman$_{N/A}$ who$_{N/A}$ the girl$_{N/A}$ saw had
auch der Mann gesehen.
also the man$_{N}$ seen
'The woman that (saw the girl/the girl saw) had also been seen by the man.'[4]

The relative clause is syntactically ambiguous due to the ambiguity in the case marking. In German, there is a strong and extremely well-studied parsing preference for interpreting such clauses as having a subject-initial, that is, as having subject-object order (Hemforth 1993; Bader & Meng 1999; beim Graben *et al*. 2000; Schlesewsky *et al*. 2000; Schlesewsky & Friederici 2003). In the main clause, the unambiguously nominative marked subject appears in final position and is preceded by *auch*. Assuming that *auch* is understood as being unstressed (a plausible assumption for function words), it associates with an expression that follows it (for a discussion of stressed v. unstressed *auch*, see Krifka 1999), here most naturally the subject (*der Mann*), which yields the presupposition that someone else had seen the woman. This presupposition is not satisfied on the syntactically preferred subject-initial interpretation of the relative clause. However, the syntactically dispreferred object-initial interpretation of the relative clause (that the girl saw the woman) *does* satisfy this presupposition.

The task for the participants then was to choose a paraphrase that best matched their understanding of the sentence. The paraphrases for (4) would have been 'The man and the girl saw the woman' and 'The woman saw the girl and the man saw the woman'. This choice between paraphrases amounted to a choice between the syntactically preferred interpretation and the interpretation on which the presupposition of *auch* was satisfied. As a control condition, the same sentence was used

[4] Here and below, the passive is only used in the English paraphrase to keep the word order similar to the German one. Note that the sentences given here are only used for illustration purposes and were not used in the actual studies. Samples of the experimental materials are provided in Appendix.

except that *auch* was replaced by *vorher* (here best translated as *earlier*), which does not introduce any presupposition whose satisfaction depends on the interpretation of the relative clause. Two further conditions followed the same basic idea, but had the order of the clauses reversed, with *auch* appearing in the relative clause. An example is given in (5).

(5) Die Frau sah das Mädchen, das auch den
The woman$_{N/A}$ saw the girl$_{N/A}$ who$_{N/A}$ also the
Mann gesehen hatte.
man$_A$ seen had
'The woman saw the girl that had also seen the man.' or
'The woman was seen by the girl that had also seen the man.'

In this case, the matrix clause is ambiguous, and the relative clause contains *auch*. Note that this time the noun phrase *den Mann* 'the man' in the relative clause is unambiguously marked accusative, so that the clause can only mean that the girl saw the man. As above, the ambiguous clause had a syntactic parsing preference for a subject-initial interpretation, whereas the dispreferred object-initial interpretation satisfied the presupposition introduced by *auch* (that the girl saw someone else apart from the man). A control condition was again constructed by replacing *auch* by *vorher*.

Finally, a fifth condition was included, which was identical to the previous one, except that all noun phrases were ambiguously case marked:

(6) Die Frau sah das Mädchen, das auch die
The woman$_{N/A}$ saw the girl$_{N/A}$ who$_{N/A}$ also the
Lehrerin gesehen hatte.
teacher$_{N/A}$ seen had
(i) 'The woman saw the girl that had also seen the teacher.'
(ii) 'The woman was seen by the girl that had also seen the teacher.'
(iii) 'The woman saw the girl that had also been seen by the teacher.'

As a result, the sentence was three-way ambiguous.[5] Two of the readings satisfied the presupposition of *auch* [namely (ii) and (iii)], but

[5] In principle, there even is a fourth reading on which both clauses are interpreted as being object-initial. But since that reading does not satisfy the *also* presupposition, it is unlikely that this reading will come to mind.

differed in whether the matrix clause or the relative clause was interpreted as being object-initial. Therefore, the results for this condition provide a further perspective on the differences between the first two pairs of conditions.

The set-up resulted in a 2 × 2 design (plus the fifth condition, which was treated separately), with the presence or absence of *auch* as the first factor and clause order as the second factor. For the questionnaire, 30 sentences were constructed with versions for each of the five conditions above. Five versions of the questionnaire were created, varying sentences across conditions, so that each list contained six sentences per condition, resulting in a counterbalanced design. The questionnaire was created in HTML and made available online. The sentences were followed by disambiguated paraphrases and participants were asked to choose the paraphrase that matched their initial understanding of the sentence or their preferred interpretation of the sentence if more than one reading was possible. In addition to the experimental items, there were three items similar to the experimental ones, but preceded by a short text. Also, there were 20 unrelated filler items. Altogether, 90 native speakers of German completed the questionnaire.

3.1.2 *Results* The results were analysed with the percentage of the type of paraphrase chosen as the dependent variable, where the paraphrases corresponded to either the subject-initial interpretation or the object-initial interpretation. The mean percentages of how often the object-initial paraphrase was chosen are 57% and 28% in the relative clause *auch* and *vorher* conditions, respectively, and 17% and 6% in the matrix clause ones. Figure 1 illustrates this.

The object-initial interpretation was chosen more frequently in the *auch* conditions (A and C) than in the corresponding control conditions with *vorher* (B and D). It was also chosen more frequently in general for the relative clause-first order than for the matrix clause-first order. A 2 × 2 analysis of variance (ANOVA) (*auch* v. *vorher* and relative-first v. matrix-first) was performed. There was a main effect of *auch* [$F_1(1,89) = 112.3$, $p < 0.001$; $F_2(1,29) = 277.2$, $p < 0.001$] and a main effect of clause type [$F_1(1,89) = 183.3$, $p < 0.001$; $F_2(1,29) = 92.1$, $p < 0.001$]. There was also an interaction between the two factors [$F_1(1,89) = 30.7$, $p < 0.001$; $F_2(1,29) = 37.2$, $p < 0.001$]. Two-tailed *t*-tests were carried out to test for simple effects of *auch* for the two types of clause orders. Both effects were significant (condition A v. B: $t_1(89) = 10.3$, $p < 0.001$; $t_2(29) = 13.2$, $p < 0.001$, condition C v. D: $t_1(89) = 5.4$, $p < 0.001$; $t_2(29) = 7.3$, $p < 0.001$). This shows

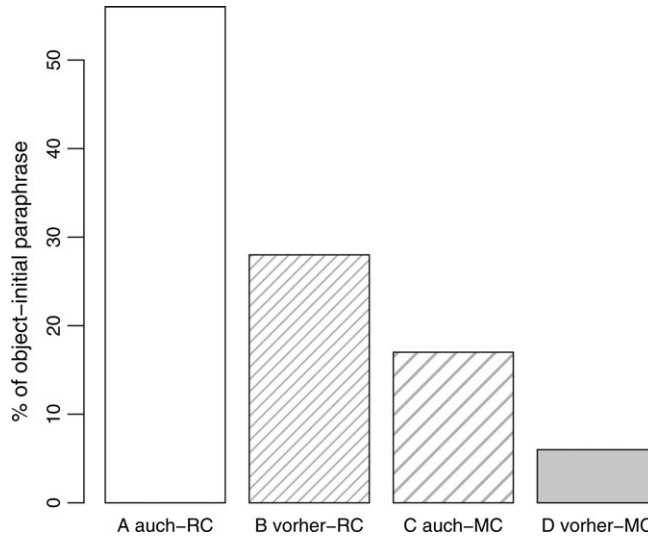

Figure 1 Percentage of object-initial paraphrases per condition.

that the differences between the *auch* and *vorher* conditions are significant for each of the clause orders. In the three-way ambiguous fifth condition, the paraphrase corresponding to the object-initial interpretation of the relative clause was chosen 43% of the time and the paraphrase corresponding to the object-initial interpretation of the matrix clause was chosen 8% of the time. The syntactically preferred subject-initial interpretation of both clauses was chosen 49% of the time.

During the initial inspection of the data, the percentage of object-initial interpretations seemed to be higher in the later parts of the questionnaire. To test whether there was a significant increase, post hoc regression analyses with order position as a factor were carried out. Since the two clause orders varied substantially in how often the object-initial paraphrase was chosen, this was done separately for the two *auch* conditions. There was no significant correlation between order position and the percentage of *B* readings for the relative clause condition ($r = .065$, $B = .1\%$, $P = 0.73$). For the matrix clause condition, on the other hand, there was a significant correlation between order position and percentage of *B* readings ($r = .544$, $B = .6\%$, $P < 0.01$). The control conditions without the presupposition patterned with the relative clause presupposition condition and did not display any significant correlation between order position and percentage of *B* readings. To test whether there actually was an interaction between the relative clause and matrix clause *auch* conditions

with respect to order position, the percentages for the *B* readings were converted into *z* scores to control for differences in variability found in the two conditions. Regressing the *z* scores of the percentage of *B* readings on order, sentence type, and order position × sentence type yielded a marginally significant interaction coefficient ($B = .054$, $P = 0.057$). We can thus conclude with fairly high certainty that the relative clause and matrix clause conditions do differ in the way order position affects the percentage of *B* readings chosen, which indicates that the two differ in the presence of practice effects.

3.1.3 *Discussion* The results from the questionnaire study clearly show that participants' choice of paraphrase is influenced by the presupposition introduced by *also*. When it is present, as in conditions A and C, the otherwise dispreferred object-initial paraphrase is chosen more frequently than when it is not, presumably because this order yields the *also* presupposition satisfied. This effect is present and significant for both clause orders, but stronger in the relative clause-first order. Altogether, the object-initial paraphrase is chosen more frequently in the relative-first order. This, together with the statistical interaction, suggests that the effect of the presupposition interacts with other parsing factors. Such an interaction is highly relevant to the question mentioned in the introduction of how exactly incremental interpretation takes place and what contribution presupposed content might make to the process of assigning meaning to linguistic input as it is being parsed.

One way of describing the process that readers might go through in reading these sentences is that they first commit themselves to a subject-initial interpretation of the ambiguous clause and then reanalyse that clause once they see that this renders the presupposition of *also* satisfied.[6] While this reanalysis is fairly unproblematic in the case of the ambiguous relative clause, it is most likely harder and involves at least one additional confounding factor in the matrix clause: interpreting the sentence-initial noun phrase as the object requires a special interpretation (e.g. as a topic), which is not supported by anything in the context. Therefore, it is altogether harder and less likely that participants will end up with the object-initial interpretation for the matrix-first order, and the effect of the presupposition is smaller in the condition with this order of clauses. An interesting further result

[6] This description assumes a non-parallel parsing architecture. I briefly discuss the relevance of the present studies to this issue of parsing architectures in section 4.3

in the statistical analysis is that there was a practice effect reflected in a significant correlation between the percentage of object-initial paraphrases chosen for the matrix-first order and the order position of the sentence within the questionnaire. For the relative-first order, there was only a small numerical increase throughout the questionnaire that was not significant. This supports the conclusion made above that it is harder to get the object-initial interpretation in the matrix-first order. Apparently, participants become more likely to choose the object-initial interpretation after having been exposed to a number of these constructions and paraphrases for the matrix-first order, whereas they start out at a fairly high level for the other clause order.

The results from the three-way ambiguous fifth condition are also important in a number of ways. First they support the point made at the end of the last paragraph, since they show that what is behind the object-initial paraphrases being chosen less often in the matrix clause-first condition really is that the matrix clause has to be reanalysed. In the three-way ambiguous condition, either clause could have been given the object-initial interpretation in order to satisfy the *also* presupposition. But again, we find a strong asymmetry between the relative clause and the matrix clause, with 43% object-initial paraphrases chosen for the relative clause and only 8% object-initial paraphrases for the matrix clause. This asymmetry shows that the differences between the matrix-first and the relative clause-first conditions are not due to parallelism, as one might be tempted to hypothesize, since the object-initial interpretation of the relative-first conditions results in both clauses having the same order, whereas the matrix-first conditions have non-parallel orders on that interpretation. Furthermore, the asymmetry helps to fend off another alternative hypothesis, namely, that the higher percentage in object-initial interpretations for the relative-first order is due to the obligatory object-initial interpretation of the matrix clause. But since the object-initial paraphrase of the relative clause was chosen so frequently in the three-way ambiguous condition, where no such obligatory object-initial interpretation was present, this explanation does not seem promising.

In sum, then, we have found that both the presupposition of *also* and the type of clause that is ambiguous have a great impact on the choice of paraphrase. The interaction seen between the effect of the presupposition and other parsing factors related to the differences between relative clauses and matrix clauses can be taken as a first indication that the evaluation of presuppositions with respect to their context takes place in online processing, although we need to be cautious in drawing any firm conclusions in this regard from an offline

questionnaire study. The experiment reported in section 3.2 attempts to address this issue in a more direct way.

3.2 *Self-paced reading study on auch*

3.2.1 *Methods and materials* The second experiment used the self-paced reading method to investigate the effect of presuppositions on the time people spend reading the relevant parts of the experimental sentences. For this study, the basic strategy was to present morpho-syntactically unambiguous versions of the materials in the first experiment, which varied in whether the presupposition of *also* was satisfied or not. To disambiguate the sentences, masculine, rather than feminine or neuter noun phrases were used in the critical positions, so that the case marking on the definite article was unambiguously nominative (*der*) or accusative (*den*). Since the effect in the questionnaire was larger for the relative-first order, sentences using this order were used for the online study. An example illustrating the set-up of the experimental items is given in (7).[7]

(7) a. Die Frau,/ die der Junge sah,/ hatte auch der
The $\text{woman}_{N/A}$ $\text{who}_{N/A}$ the boy_{N} saw had also the
Mann gesehen.
man_{N} seen
'The woman that the boy saw had also been seen by the man.'

b. Die Frau,/ die den Jungen sah,/ hatte auch der
The $\text{woman}_{N/A}$ $\text{who}_{N/A}$ the boy_{N} saw had also the
Mann gesehen.
man_{A} seen
'The woman that saw the boy had also been seen by the man.'

In the sentence in (7a), the noun phrase in the relative clause (*der Junge* 'the boy') is unambiguously marked nominative, which results in the clause being object-initial and meaning that the boy saw the woman. The main clause contains *auch*, which (again assuming that it associates with *der Mann* 'the man') introduces the presupposition that someone else saw the woman. Given the meaning of the relative clause, this presupposition is satisfied. In (7b), on the other hand, the noun

[7] As before, this example is only used for illustrative purposes. See Appendix for a sample of the actual materials used in the experiment. The slash indicates the frame breaks between the parts of the sentence that were displayed at one time in the moving-window display (this is described in more detail below).

phrase *den Jungen* 'the boy' is unambiguously marked accusative, so that the relative clause is subject-initial and can only be understood as the woman seeing the boy. The presupposition of the main clause is as in (7a), and is therefore not satisfied by the relative clause. If we found any reading time effects related to whether or not the presupposition is satisfied (and which did not show up in the controls), this would tell us that information about presupposition satisfaction has to be available to the processor at that time, and hence that any semantic processes necessary to determine presupposition satisfaction must have already taken place.

As in experiment 1, control conditions were constructed by replacing *auch* with *vorher*. As before, this resulted in a 2 × 2 design, with the presence or absence of *auch* as the first factor and subject-initial v.object-initial structures as the second factor. The experiment included 24 sentences with versions in each of the four conditions. The sentences were counterbalanced across conditions in four lists. Participants only saw each sentence in one condition. The experiment was programmed using E-Prime software. The presentation order of the items was randomized. Sentences were presented using the moving-window technique. On the first screen, all characters were replaced by underscores. Participants had to press the space bar to see the first part of the sentence. When they pressed the space bar again, the first part was replaced by underscores, and the next part of the sentence was displayed. Reading times were recorded for each displayed phrase.

After each sentence, a yes–no question about that sentence was presented, and participants had to push 's' to answer 'yes' and 'k' to answer 'no'. Half of the questions asked about the relation in the relative clause ('Did the boy see the woman?'[8]) and the other half about the relation in the matrix clause ('Did the man see the boy?'). Overall, half of the questions had 'yes' as a correct answer and half of them 'no'. For the relative clause questions, the correct answer varied across conditions, since the relation depended on the experimental manipulation of subject- v. object-relative clauses. Both the responses and the response times were recorded.

Apart from the experimental items, there were 72 items from unrelated experiments and 12 from a related experiment. Furthermore, there were 12 filler items. Subjects were instructed that they were going to read sentences on the screen and that they had to answer short questions about them, which did not necessarily have right or wrong answers. They also were told to answer questions with 'yes' only if this

[8] For examples of the actual questions, see the materials in Appendix.

followed directly from the sentence in question and that they had to press the 's' key for 'yes' and the 'k' key for 'no'. On average it took about 30 minutes to complete the experiment. In total, 20 native speakers of German participated in the experiment.

3.2.2 *Results* The measure of most interest was the reading times on the clause containing *auch* (or *vorher*). Their means were 3555 and 4911 ms in the object-initial conditions with *auch* and *vorher*, respectively, and 5469 and 4480 ms in the subject-initial ones. They are illustrated in Figure 2.

When *auch* was present, the reading time in the object-initial condition A (where the presupposition of *auch* was satisfied) was almost two seconds faster than in the subject-initial condition C (where the presupposition was not satisfied). When *auch* was replaced by *vorher*, the subject-initial condition (D) had a small advantage over the object-initial condition (B). Interestingly, the *auch* phrase was read almost 1.5 seconds faster than the *vorher* phrase in the object-initial condition (A v. B), but roughly one second slower in the subject-initial condition (C v. D).

A 2 × 2 ANOVA revealed an interaction between the two factors [$F_1(1,19) = 26.00$, $P < 0.001$; $F_2(1,23) = 17.81$, $P < 0.001$]. In addition, there was a main effect of order (subject-initial v. object-initial) [$F_1(1,19) = 11.58$, $P < 0.01$; $F_2(1,23) = 7.88$, $P = 0.01$], which

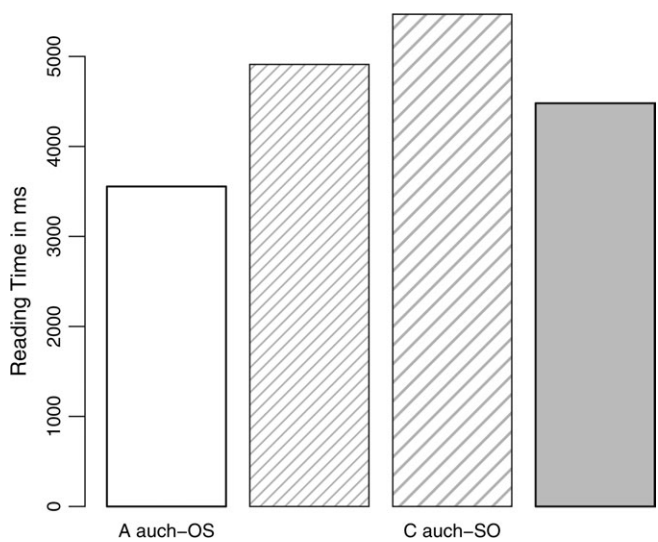

Figure 2 Reading time on final clause in milliseconds.

was dominated by the interaction. A number of *t*-tests were also carried out to test for simple effects of *auch* v. *vorher* and object-initial v. subject-initial relative clauses separately. The difference between conditions A and C was significant [$t_1(19) = -6.49$, $P < 0.001$; $t_2(23) = -4.58$, $P < 0.001$], which shows that there was a simple effect of subject-initial v. object-initial structures in the *auch*-conditions. There also was a significant difference between A and B [$t_1(19) = -4.72$, $P < 0.001$; $t_2(23) = -5.03$, $P < 0.001$], that is, a simple effect of *auch* in the object-initial conditions. The difference between C and D was significant by subject and near significant by items [$t_1(19) = 3.07$, $P < 0.01$; $t_2(23) = 1.96$, $P = 0.06$], but the difference between B and D was not significant [$t_1(19) = -1.28$, $P = 0.22$; $t_2(23) = 1.25$, $P = 0.23$]. In terms of the statistical analysis, then, the main results are the interaction between the two factors and the simple effect of the order of subject and object in the relative clause. The simple effect of *auch* in the object-initial conditions is of interest as well, but its interpretation is less clear as it could in principle be due to a lexical effect involving *auch* and *vorher*.[9]

Taken together, these results show that the reading times in the *auch* conditions were strongly influenced by subject-initial v. object-initial order (corresponding to whether the presupposition of *auch* is satisfied or not), while the reading times in the *vorher* conditions were only slightly influenced by this factor, and in the opposite direction.

The data for the relative clause region were analysed as well to provide a comparison with the effects in the *auch* region. The reading times by condition were as follows:[10] condition A 3615 ms, condition B 3776 ms, condition C 3648 ms and condition D 3429 ms. A 2 × 2 ANOVA did not find any significant effect.

As additional measures, the response times and the accuracy rates for the yes–no questions following the display of the sentence were also analysed. In the response times, there was a main effect of order, with the object-initial conditions having roughly an advantage of one second over the subject-initial conditions [object-initial: 3885 ms,

[9] In light of the fairly low accuracy rates, an anonymous reviewer suggested to also analyse the data by only looking at data points from sentences to which the subjects had responded correctly. The overall pattern of the data looked very similar: condition A: 3582 ms, B: 4916 ms, C: 5079 ms, D: 4648 ms. The interaction was significant [$F_1(1,19) = 9.85$, $P < 0.01$; $F_2(1,23) = 10.80$, $P < 0.01$]. The main effect of order was only marginally significant by subjects, but significant by items [$F_1(1,19) = 3.73$, $P = 0.07$; $F_2(1,23) = 6.24$, $P < 0.05$]. The simple effect comparing conditions A and C was still present, [$t_1(19) = -3.34$, $P < 0.01$; $t_2(23) = -3.90$, $P = 0.001$], as was the simple effect comparing A and B [$t_1(19) = -3.78$, $P = 0.001$; $t_2(23) = -4.59$, $P < 0.001$].

[10] After removal of eight outliers that were over 3 standard deviations (SDs) from the mean of each condition (RTs over 10 s).

subject-initial: 4960 ms, $F_1(1,19) = 16.4$, $P = 0.001$; $F_2(1,23) = 16.41$, $P < 0.001$].[11] There was no significant interaction and no other significant main effect. Response times were faster when the correct response was 'yes' (3955 ms) than when it was 'no' (4996 ms) [$t_1(19) = 2.54$, $P < 0.05$][12] and correct answers (4134 ms) were faster than incorrect answers (5878 ms) [$t_1(1,19) = 4.08$, $P = 0.001$; $t_2(1,23) = 3.80$, $P = 0.001$].

The overall mean accuracy rate was 81.25%.[13] There was a main effect of order [$F_1(1,19) = 7.69$, $P < 0.05$; $F_2(1,23) = 5.11$, $P < 0.05$], with means of 86.25% for the object-relative clause conditions and 76.17% for the subject-initial ones. There was no significant interaction and no other significant main effect. Accuracy in the object-relative clause condition with *auch* (85%) was higher than in the subject-initial one (73%) [$t_1(19) = 2.67$, $P < 0.05$; $t_2(23) = 1.94$, $P = 0.07$], which indicates a simple effect of presupposition satisfiction, with higher accuracy rates when the presupposition was satisfied. There was a numerical difference between questions that asked about the relative clause (78%) and those that asked about the matrix clause (85%), which could simply be due to recency of the phrase asked about. Accuracy was the lowest when both of these last two factors were considered in combination, namely in the subject-relative clause condition with *auch* when the question was about the relative clause (67%). It was highest, on the other hand, in the object-relative clause conditions when the question was about the matrix clause (91.5%), in which case the presupposition is satisfied and the question is about the most recently seen part of the sentence. Looking at order, *auch*, and question type together in a three-way ANOVA, there was a marginally significant three-way interaction [$F(1, 19) = 4.04$, $P = 0.06$]. This suggests that some of the questions were particularly hard in certain conditions and that the relatively low overall accuracy rates were predominantly due to these combinations of questions and conditions. Whether the correct response was 'yes' or 'no' did not alter accuracy rates significantly ('yes': 82%, 'no': 80%). In summary, the question response times and accuracy rates did not display the *auch* × order interaction, but were predominantly affected by order. This

[11] The effect of order on response times was also significant when including only the data for correct responses [object-initial: 3633 ms, subject-initial: 4754 ms; $F_1(1,19) = 18.45$, $P < 0.001$; $F_2(1,23) = 12.81$, $P < 0.01$].

[12] Analyses involving this factor as well as the question type factor below were only done by subjects, since the levels of these factors were not varied systematically within items.

[13] The numbers and results for the accuracy rates reported here differ from those previously reported in Schwarz (2006), because a error was discovered during a re-examination of the data.

might well be due to the fact that it was easier to keep the relations in the relative clause and the matrix clause straight when they were parallel (the woman was seen by the boy and the man) than when they were not (the boy was seen by the woman and the woman was seen by the man). In terms of simple effects, both recency of the phrase asked about and the satisfaction of the *auch* presupposition affected accuracy.

3.2.3 *Discussion* The results from the self-paced reading study clearly show that the reading time on the final clause containing *also* was substantially affected by whether the presupposition of *also* was satisfied or not. This is not merely an effect of parallel order in the two clauses, as the effect was reversed in the *earlier* conditions, in which no relevant presupposition interfered. Interestingly, this effect was not reflected in the accuracy rates or the question response times, which only exhibited main effects but no interaction of *also* and order. Nonetheless, a simple effect of presupposition satisfaction showed up in the accuracy rates.

The effect of the presupposition is rather large, at almost two-second difference between conditions A and C. It is very likely that this is due to the relatively demanding task, especially in certain conditions, of answering the yes–no questions that followed the display of the sentence. Almost all subjects reported that it was often quite difficult to keep in mind who did what to whom amongst the three people talked about in each sentence. When the presupposition did not match the content of the relative clause, it must have been even harder to keep this information straight, and this may have caused rather substantial delays when reading the final part of the sentence. The simple effect of presupposition satisfaction on the accuracy rates supports this as well. In connection with this, one particularly telling comment made by a participant after the experiment was that she thought there were some spelling mistakes in the sentences, especially with respect to the case marking on noun phrases (e.g. *der Mann* rather than *den Mann*). Apparently, the expectation raised by the presupposition of *also* was so strong that the mismatch was perceived as a mistake. One thing that is remarkable about this is that when sentences like those in the unsatisfied *also* condition are seen out of context and without the question, they do not stand out much at all (the reader can make his/her own judgment about the corresponding English examples in experiment 3). It thus seems like the presence and nature of the questions contributed substantially to the slow reading times and large effect sizes.

The strong effect on the reading time suggests that the presupposed content is evaluated online. This lends further support to the speculative

conclusion above that the results from the questionnaire study are based on online effects of presuppositions. This finding is consistent with the results from previous studies on the presuppositions of definite descriptions that were mentioned above (e.g. Crain & Steedman 1985; van Berkum *et al*. 2003). An additional point of interest here is that the reading times for the clause containing *also*, preceded by the relative clause that satisfied the *also* presupposition (A), were faster than the reading times for the same clause with *earlier* preceded by the same relative clause (B). However, it is possible that this is simply a lexical effect of *also* compared to *earlier*. If this difference turned out to be real, it could be taken to tell us something interesting about the role of presupposed content in natural language. The advantage of the *also* condition might be that the presupposed content facilitates the integration of new content into the contextual representation by connecting new and old information. Since this effect was not replicated in experiment 3 discussed below, we should be careful not to overinterpret the effect at this point.

While the results in general reinforce the conclusion that there are online effects of presuppositions, a number of questions remain open that might undermine the interpretation of these results to some extent. First, the critical region was the final region, which makes it impossible to distinguish between online effects during the actual reading and potential sentence-final wrap-up effects. Secondly, the rather slow reading times and the large effect size, together with the rather low accuracy rates in some conditions, give rise to the possibility that the effects found are due to the task demands of answering the questions. Another worry in this direction is that the well-documented subject-relative clause advantage did not show up significantly in the relative clause reading times.[14] Finally, the possibility of the *also* v. *earlier* advantage being a lexical effect keeps us from drawing any strong conclusions in this respect.

3.3 *Self-paced reading study on also*

3.3.1 *Methods and materials* In order to address the issues with the German self-paced reading study raised above, a follow-up study was undertaken in English. The additive particle chosen for this study was *also*, rather than *too*, in order to allow for a similar paradigm where other adverbials could replace *also* in the control conditions. The main new features introduced in this study were that the critical region was

[14] Part of the reason for this may be that a large number of object-initial structures were presented throughout the various experiments included in the self-paced reading study.

non-final, that no questions were asked (although there were filler items and items from other studies for which questions had to be answered), and that a range of different adverbs were used for the control conditions (e.g. *just*, *once*, *almost*, *recently*, *now*). An example from the materials is provided below.[15]

(8) a. The congressman/ who wrote to John/ had also written to the mayor/ to schedule a meeting/ for the fundraiser.
b. The congressman/ who wrote to John/ had just written to the mayor/ to schedule a meeting/ for the fundraiser.
c. The congressman/ who John wrote to/ had also written to the mayor/ to schedule a meeting/ for the fundraiser.
d. The congressman/ who John wrote to/ had just written to the mayor/ to schedule a meeting/ for the fundraiser.

In the English set-up, unlike in the German set-up, the matrix clause is subject-initial, which means that it is now the subject-initial relative clause (a) that satisfies the presupposition of *also*.

One additional manipulation was introduced in this experiment: whereas half of the items had the same verb in the relative clause and in the matrix clause, the other half had two different verbs in the two clauses. These two verbs were more or less synonymous and were all chosen in such a way that the verb in the relative clause implied the verb in the matrix clause (at least in the specific usage in the sentence). An example is given in (9).

(9) a. The lawyer/ who contacted Allison/ will also get in touch with her neighbors/ to discuss the problems/ with the new zoning law.
b. The lawyer/ who contacted Allison/ will later get in touch with her neighbors/ to discuss the problems/ with the new zoning law.
c. The lawyer/ who Allison contacted/ will also get in touch with her neighbors/ to discuss the problems/ with the new zoning law.
d. The lawyer/ who Allison contacted/ will later get in touch with her neighbors/ to discuss the problems/ with the new zoning law.

Apart from making the materials more diverse and more natural, this served as a first attempt to shed light on an important question about the properties of the levels of representation at which the processes studied here take place. The intuitive idea is that seeing that the presupposition of *also* is satisfied might be easier when the very

[15] See Appendix for more examples from the materials.

same verb appears in both clauses than when there are two different verbs that are in an implicational relation. In the former case, it can be read off the surface structure (or a representation very close to it) that the presupposition is satisfied, while in the latter case, additional inferences have to be made to the extent that, speaking in terms of the example above, 'contacting Allison' will do in order to satisfy the presupposition that the lawyer got in touch with someone else apart from the neighbours.

In DRT approaches to presupposition (van der Sandt 1992; Geurts 1999), the process of evaluating presuppositions makes reference to formal properties of DRSs. It might be possible, then, to decide whether or not an anaphoric presupposition is satisfied by only considering a formal level of representation that is close to the surface structure (i.e. a level where the relationship between 'contact' and 'get in touch' is not transparent).[16] In the case of the same-verb condition, it would be possible to determine that the presupposition of *also* is satisfied based on such a representation, since the predicates would be formally identical [say, *contact*(*x*)(*y*)]. But in the different-verb condition, this would not be possible, because it can only be determined based on the meaning of the two verbs that the *also* presupposition is satisfied.

From a processing perspective, checking whether the presupposition is satisfied should then be computationally cheaper in the same-verb condition than in the different-verb condition. This is the case at least, for the conditions where the presupposition is satisfied. If it is not, the processor presumably would go through the same steps in both cases, trying every possibility to get the presupposition satisfied. This hypothesis would therefore predict an interaction between the presupposition effect familiar from experiment 2 and the same-verb v. different-verb factor.

While it would be easy to capture such an effect in DRT, it would not be expected for a theory like File Change Semantics and other dynamic theories that do not make reference to representational structures. Hence, such a result would strongly support an approach to presupposition resolution processes that involve reference to formal properties of representations, like DRT.

The procedures for this experiment were the same as in experiment 2, except that no questions were asked after the experimental items. The study included 60 items from three unrelated experiments as well

[16] But note that this is by no means a necessary feature of any DRT account, and hence a negative or non-confirming outcome would not be evidence against DRT.

as 40 filler items. Most of these other items were followed by a question. A total of 48 undergraduates from the University of Massachusetts Amherst participated in the experiment.

3.3.2 *Results* As in experiment 2, the main interest was in the reading times on the region containing *also*. The means are shown by condition in Table 1.[17]

A 2 × 2 ANOVA was performed on the data. There was a significant interaction [$F_1(1,47) = 4.55$, $P < 0.05$; $F_2(1,23) = 5.57$, $P < 0.05$] and a main effect of order [$F_1(1,47) = 15.61$, $P < 0.001$, $F_2(1,23) = 12.19$, $P < 0.05$]. Finally, there was a main effect of *also* that was significant by items [$F_1(1,47) = 2.33$, $P = 0.134$; $F_2(1,23) = 4.92$, $P < 0.05$]. Turning to simple effects, the subject-relative clause condition with *also* was faster than the object-initial one [$t_1(47) = 4.16$, $P < 0.001$; $t_2(23) = 3.97$, $P = 0.001$]. The only other significant simple effect was comparing the object-relative clause condition with *also* to the one with another adverb [$t_1(47) = 2.31$, $P < 0.05$; $t_2(23) = 3.39$, $P < 0.05$]. In summary, we find the same interaction as in experiment 2, as well as main effects that are dominated by the interaction.

The reading times for the same- and different-verb conditions are presented in Table 2. In numerical terms, the two-way interaction seems to be present in both conditions, with the advantage of condition A over C being bigger than the advantage of B over D. Including the factor of verb sameness in the analysis by running a three-way ANOVA (order × *also* × verb) did not yield a significant three-way interaction [$F_1(1,46) = .34$, $P = 0.56$; $F_2(1,22) = .37$, $P = 0.55$]. Reading times were slightly higher in the different-verb conditions, which was reflected in a main effect of verb sameness that was significant by items and marginally significant by subjects [$F_1(1,46) = 3.44$, $P = 0.07$; $F_2(1,22) = 4.47$, $P < 0.05$]. The main effects of order and the order × *also* interaction were also significant. There were no other significant effects.

In terms of the hypothesized stronger effect in the same-verb condition, the numerical results go in the opposite direction of what we would expect if the representations would facilitate the process of checking whether the presupposition is satisfied. While the difference between the two *also* conditions is slightly bigger in the same-verb conditions than in the different-verb conditions (227 v. 196 ms), the difference in the corresponding control conditions patterns the other

[17] Outliers that were over 3 SDs from the mean of their condition were excluded from the analyses. This removed 2.2% of the data points.

Condition	A	B	C	D
RTs in ms	1601	1633	1821	1692

Table 1 Reading times on *also* region

Condition	A	B	C	D
Same verb: RTs in ms	1540	1554	1767	1682
Different verb: RTs in ms	1635	1674	1829	1693

Table 2 Reading times on *also* region

way (128 v. 19 ms), so that the advantage of the satisfied *also* presupposition is actually bigger in the different-verb condition when viewed relative to the control conditions.

Turning to the relative clause region, the subject-relative clauses (1382 ms) were read significantly faster than the object-relative clauses (1667 ms), which was reflected in a main effect of order [$F_1(1,47) = 15.97$, $P < 0.001$; $F_2(1,23) = 19.18$, $P < 0.001$]. No other effects were significant. This effect illustrates the well-known advantage of subject-relative clauses over object-relative clauses.

Finally, since there were two additional regions following the *also* region, we should also look at the reading times for the region immediately following the one with *also*. The mean reading times are shown in Table 3.[18] A 2 × 2 ANOVA did not find a significant interaction. There was a main effect of order [$F_1(1,47) = 3.76$, $P = 0.06$; $F_2(1,23) = 5.58$, $P < 0.05$]. The only significant simple effect was between the subject-initial and the object-initial *also* conditions [$t_1(47) = 2.12$, $P < 0.05$; $t_2(23) = 2.08$, $P < 0.05$]. Thus, although there seems to be some spillover from the *also* region yielding this simple effect, the bulk of the effect we are looking at is confined to the region containing *also*.

3.3.3 *Discussion* Experiment 3 avoided some of the shortcomings of experiment 2, discussed above. Although no specific task other than reading the sentences was performed, we found the same interaction effect as before. The reading times in experiment 3 were much shorter than in experiment 2, and the effect between the subject-relative clause and the object-relative clause *also* conditions is in the order of 200 ms.

[18] Again, outliers over 3 SDs from the condition means were excluded from the analyses.

Condition	A	B	C	D
RTs in ms	890	904	969	931

Table 3 Reading times on region after the *also* region

This is about the same size as the subject-relative clause advantage found in the relative clause region, which was around 250 ms. Furthermore, the effect in its full form showed up only on the region containing the *also*, with minimal spillover to the following region. This excludes the possibility that we are only dealing with sentence-final wrap-up processes. Finally, the difference between the subject-relative clause *also* and adverb conditions (corresponding to the object-relative clause conditions with *auch* and *vorher*) was not replicated in experiment 3, which suggests that in experiment 2 this difference reflected a lexical effect or that it was task specific in that it was helpful in answering the questions asked after each sentence.

With respect to the newly introduced factor, which varied between having identical and different verbs in the relative and matrix clauses, no relevant interaction effect of verb sameness could be determined. Assuming that presupposition resolution can take place on a representational level close to the surface structure, we would have expected a stronger effect in the same-verb conditions. But there is no evidence of it being harder to see that the presupposition of *also* was satisfied in the different-verb condition than in the same-verb condition. Numerically the reading times patterned in the opposite way, with a larger advantage of the satisfied *also* condition in the different-verb conditions (relative to the control conditions). However, these results are inconclusive since they are not significant.

A number of theoretical issues arise in connection with the results of the experimental studies reported here, which in turn have the promise of providing new approaches for empirical research on presuppositions. I turn to these points in section 4.

4 THEORETICAL IMPLICATIONS

Ideally, results from psycholinguistic studies can contribute to theory in two directions, which correspond to the following two questions: what do the results tell us about (the relevant part of) linguistic theory, and what can we learn from them with respect to processing theories? I will focus on the implications for semantic theory, which I turn to in

sections 4.1 and 4.2. A few brief remarks about related processing issues are made in the final part of this section.

4.1 *Implications for the semantics of additive particles*

First, let us turn to the implications that the results presented above have for the analysis of additive particles like *also* and *auch*. In experiment 1, the fact that the presupposition of *also* was not satisfied on the syntactically preferred analysis of the sentence resulted in a significant increase of the percentage with which the paraphrase corresponding to the syntactically dispreferred analysis was chosen. And in the self-paced reading studies, there were significant delays in the reading times when the presupposition was not satisfied.

These very strong effects of presupposition failure are relevant for the analysis of the presupposition of additive particles like *too*, *auch* and *also*. As was discussed in section 3, Kripke (1991) argued that *too* differed from many other presupposition triggers in that its presupposition strongly resists accommodation. Following Kripke, current proposals assume that their presupposition is at least partly anaphoric, which means that they require an antecedent of some sort in the discourse context (Heim 1992; van der Sandt & Geurts 2001).

Let us take a closer look at the formulation of an anaphoric analysis of *also* in connection with the experimental materials. I will focus on the English examples from experiment 3 for ease of exposition, but the same points of course apply to the German studies. Heim's analysis of *too* (adapted here for *also*) is provided in (10a). Note that the presupposed x has to correspond to a discourse referent that is already in the context. This is what captures the anaphoricity of *also*. In (10c), this analysis is applied to the example sentence for condition A.

(10) a. Presupposition of *also* in general (Heim 1992)[19]
Φ *also*$_i$ $[\alpha]_F$ presupposes $x_i \neq \alpha$ *in* c & $\Phi(x_i)$

b. The congressman who wrote to John had also written to the mayor ...

c. Presupposition of *also* in (a) (with focus on *the mayor*)
$\lambda x.$ *write*(*congressman*, x) *also* $[$*the mayor*$]_F$ presupposes
$x_i \neq$ *the mayor in* c & *write*(*congressman*, x_i)

The presupposition introduced by *also*, that there is another individual in the discourse context, apart from the mayor, to whom the congressman wrote, is satisfied by the information in the relative

[19] For a recent formulation of this idea within DRT and discussion of some further issues, see van der Sandt & Geurts (2001).

clause, which states that the congressman wrote to John. Crucially, this requires that the matrix clause is evaluated with respect to a context that contains the information in the relative clause—this will be discussed in detail in section 4.2. For the moment, let us focus on the cases where the order in the relative clause is switched around ('. . . who John wrote to . . .'), which results in there not being any individual in the discourse that the congressman had written to and the presupposition not being satisfied. These were the syntactically preferred analyses of the ambiguous sentences in the questionnaire study (experiment 1) and the object-initial relative clause condition C in experiment 3.[20] In the former case, we found that this led to the paraphrase corresponding to the syntactically dispreferred analysis being chosen more often (which yielded the presupposition satisfied). In the latter, we found substantial delays in the reading times on the region containing *also*. Since the contrast in presupposition satisfaction between conditions A and C is the only relevant difference that is not also present in the control contrast between B and D, we can conclude that the reading time differences between A and C (that is not present between B and D) are due to this difference in presupposition satisfaction.

These results are very much consistent with the claim that the presupposition of *auch* and *also* cannot be accommodated, and with accounts that take this aspect into consideration, for example the one above, for which van der Sandt & Geurts (2001) have argued that it is due to the anaphoric aspect of the presupposition of *too* that it cannot be accommodated. In the case of the ambiguous questionnaire items, the only way to save the sentence from presupposition failure, then, is to override the strong syntactic preference for the initial analysis of the ambiguous clause. And in the case of the unambiguous self-paced reading materials, the inability to accommodate leads to a substantial slow down in reading. On the other hand, the results are unexpected on earlier proposals, for example, the one by Karttunen & Peters (1979), which assumed that additive particles like *too* merely have an existential presupposition. It is hard to imagine how a merely existential presupposition, which should not be too hard to accommodate, could have such strong effects in processing, especially given that it has proven to be difficult to find effects of accommodation for other presupposition triggers like the definite article, which also is generally assumed to have an existential presupposition (for a recent discussion, see Frazier 2006).

[20] In experiment 2, it was the subject-initial relative clause condition, because the matrix clause was object-initial and hence required an object-initial relative clause in order for the *also* presupposition to be satisfied.

While Kripke's example in (3a) above already provides a strong argument against such a proposal, the difficulty of accommodating the presupposition of *auch* and *also* in the present experiments can be taken as further evidence against an existential account.

In summary, the present experiments can be taken as evidence for the impossibility (or at least great difficulty) of accommodating the presupposition of *auch* and *also*. Consequently, they also provide support for accounts that can explain this property, such as the anaphoric account.

4.2 *Implications for semantic theory*

In this section, I turn to the issue of how the experimental results relate to the bigger issue of how the parser makes use of the semantic part of the grammar and what implications this might have for semantic theory in general. To begin with, let us briefly consider some general aspects of the relevant questions. I take it to be the null hypothesis that the processor makes use of the grammar when parsing linguistic input. It may have additional principles that help to rule out many of the grammatical analyses of the structure that might in principle be possible, but it certainly should make use of the grammatical system to exclude ungrammatical analyses. If we can conclude from experimental results that the processor has access to certain information for a given structure, then we can conclude that the grammatical system must function in a way that allows it to provide this information to the parser at that point and on the basis of the information available at the time. This is the general form of the line of argumentation taken below. To anticipate, I will argue that the processor evaluates the *also* clauses from the self-paced reading materials with respect to the preceding noun phrase (including the relative clause), which means that the semantic component of the grammar must have made it possible to integrate the content of that noun phrase into the representation of the context when it encounters the *also* clause. This means that the processing results constrain us in formulating grammatical theories in that they have to be compatible with the incremental steps found in presupposition interpretation in the reported experiments.

We have seen in section 4.1 that the processing effects depend on whether or not the content of the relative clause in the experimental materials satisfies the presupposition of *also* in the matrix clause. As far as the processing perspective is concerned, the process of determining this seems to take place online, since the effect shows up in the reading time on the clause that contains the presupposition trigger.

This suggests that as one is reading the part of the sentence containing *also*, one is aware of the content of the relative clause (of course, that also matches our intuitive sense of what happens when we read). When we look at processing in terms of dynamic semantics, this is rather interesting: to evaluate the presupposition of *also* is to check whether the context entails it (and in the case of *also*, it also involves something like checking whether there is an appropriate discourse entity having the relevant property). Since the sentence is not at all problematic in any way (neither intuitively nor in terms of the reading time results), it seems to be the case that the content of the relative clause is already integrated into the representation of the context by the time the part of the sentence containing *also* is semantically processed. In other words, it looks as if the representation of the context has been updated with the sentence-initial noun phrase, including the relative clause, by the time the next part of the matrix clause is interpreted.

Let us now turn to a more detailed analysis of what the grammar has to provide for the processor. If we think of updates of the representation of the context as only taking place at the level of a sentence or a full clause, we cannot explain how the initial noun phrase can satisfy the presupposition: if we try to apply the context change potential of the entire sentence to the neutral context, the update would fail, since the presupposition of *also* is not satisfied in the initial context (and no repair would work, since the presupposition of *also* cannot be accommodated). However, as I already mentioned in section 2, in the full version of File Change Semantics of Heim (1983b), contexts consist of sets of pairs of worlds and assignment functions, and noun phrases denote atomic propositions (and hence have complete context change potentials of their own). The meaning of definite and indefinite noun phrases is as in (11), with the difference between definite and indefinite ones being captured with the Novelty Condition in (11b).[21]

(11) a. Let c be a context (here a set of assignment functions)
and let p be an atomic formula, then, if defined :
$c + p = \{g : DOM(g) = \cup Dom(f)\ s.t.\ f \in c \cup \{i : x_i \text{ occurs in } p\}$
& g is an extension of one of the functions in c & g verifies $p\}$

b. The Novelty/Familiarity Condition
$c + p$ is only defined if for every NP_i that p contains,
if NP_i is definite, then $x_i \in Dom(c)$, and
if NP_i is indefinite, then $x_i \notin Dom(c)$.

[21] For simplicity, I restrict the formal characterization of contexts to sets of assignment functions.

With denotations such as these, the progression of updates of the representations of the context for the sentences of condition A can proceed without a problem. First, the initial noun phrase is interpreted and its presupposition is evaluated with respect to the input context. It is not satisfied, but it can be accommodated without a problem. Next, the rest of the matrix clause is interpreted, and the presupposition of *also* is evaluated with respect to the local context. In this context it is satisfied, and the update can proceed smoothly. The semantic characterization of these steps is sketched in semiformal terms in (12).

(12) p : The congressman x that wrote to John
q : x also wrote to the mayor
a. $c + p$ defined only if
there is a unique congressman that wrote to John
b. after accommodation:
$c + p = \{g\text{: } g \text{ verifies } \mathit{congressman}(x) \ \&\ \mathit{write}(x)(\mathit{john})\} = c'$
c. $c' + q$ defined only if there is a $z \neq \mathit{the\ mayor\ in}\ c'$ & $\mathit{write}(x)(z)$
defined, since the congressman wrote to John, hence
$c' + q = \{g\text{: } g \text{ verifies } \mathit{congressman}(x) \ \&\ \mathit{write}(x)(\mathit{john}) \ \&$
$\mathit{mayor}(z) \ \&\ \mathit{write}(x)(z)\}$

This contrasts with condition C, where the order in the relative clause has been switched around, so that even after the initial noun phrase has been integrated into the representation of the context by the time the rest of the matrix clause is interpreted, the presupposition of *also* is not satisfied, and there is no chance to accommodate it, since the presupposition of *also* resists accommodation. The presence of this effect requires that the semantic analyses necessary for recognizing this contrast have been carried out by the time the *also* phrase is being read and interpreted. More specifically, the initial noun phrase, including its relative clause, must have been syntactically parsed and compositionally interpreted—the relation in the relative clause must have been fully understood by the time the presupposition of *also* is evaluated, since the A and C conditions only differ in the structure of the relative clause. In addition to these purely semantic steps of analysis, the noun phrase as a whole, being definite, needs to be accommodated prior to the evaluation of the *also* presupposition.

The results from these studies thus provide insight into the timing of compositional semantic processing, including the evaluation and accommodation of presupposed content with respect to the sentence-internal context. It is worth comparing this aspect of the present studies with previous work on definite descriptions and their presuppositions.

Recall the Crain and Steedman type of experimental design discussed in section 2. The effect found there concerned the evaluation of a definite description with respect to a context, consisting of the preceding sentence, where the uniqueness presupposition of the definite article was or was not satisfied. While this allows conclusions about the timing of the evaluation of the uniqueness presupposition, it does not reveal anything about the sentence-internal dynamics of interpretation. The studies presented here, on the other hand involve a more complex sentence-internal set-up, in which both a noun phrase with its relative clause and the relationship between *also* and its presupposition and the rest of the structure of the matrix clause have to be fully analysed and interpreted in order for the effects observed here to arise. They therefore contribute new insights to our understanding of how exactly the parser's incremental interpretation proceeds and more specifically, of the timing of when presupposed content is evaluated and integrated into the representation of the discourse context.

The more general picture that is evolving from this discussion is that in processing, the representation of the context is updated as soon as possible. Since noun phrases have context change potentials of their own, the processor can update the representation of the context as soon as it has been given a noun phrase. Further support for updates at this level comes from examples such as the following, where the presupposition of *too* is satisfied by a noun phrase which does not have any phrasal subpart as in the relative clause cases considered above.[22]

(13) a. My teacher works as a DJ too.
b. Critics of science use it, too.

Apparently, the noun *teacher* suffices to satisfy the presupposition that the relevant individual works as something else than a DJ. And the (admittedly slightly playful) example in (13b) can be understood with focus on *critics*, which introduces the presupposition that other people use science. The occurrence of *science* seems to make it salient enough that there are scientists who do science, so that the presupposition is satisfied. In addition to the level of the noun phrase, updates can, of

[22] The example in (13b) was a headline in the Valley Advocate on 1 December 2005. Kai von Fintel (personal communication) suggests that this is to be understood with focus on *use*, with *critics* as the antecedent for *too*. While agreeing that that is a possible reading, I and several other people I have consulted find the reading discussed in the text at least as plausible.

course, also occur at the level of the full clause (or any propositional level, for that matter).[23]

In summary, I conclude that the results of the experiments presented here contribute a new kind of evidence to the theoretical discussion. They show that the steps the processor goes through in interpreting a sentence, including its meaning and presuppositions, require a grammatical system for handling presupposed content that can be used to evaluate a presupposition with respect to a local context, such as the initial noun phrase in the experiments above.[24] Dynamic theories, such as File Change Semantics or DRT, seem suitable to do this job, and thus are compatible with the experimental results.

In addition to these considerations about the online studies, we should also note the relevance of the findings of the questionnaire study in this respect. Assuming a model of the syntactic parser that only pursues one structural analysis at the time, and given that there is independent evidence supporting a syntactic parsing preference for subject-initial clauses, we find a remarkable amount of effort put into reanalysis of the first clause in the questionnaire items. If that clause has initially been parsed as subject-initial, it must be revised in order to satisfy the presupposition. The fact that this revision is even considered indicates that the parser can in some sense see that the reversal of the syntactic roles of the subject and the object yields an interpretation that will just be of the right kind to satisfy the presupposition of *too*. With respect to this point, it seems crucial for the parser to have access to representations very much like the DRSs posited by DRT, since those would provide the parser with representations such as *see*(x, y), which might suffice to make the inverse of this relation accessible somehow. In connection with this, it is worthwhile noting that it seems to be fairly easy in general for the processor to invert relations when there is enough evidence, as was shown in recent work by Kim & Osterhout (2005). In this respect, we have a first bit of suggestive evidence, then, about what the relevant representations might look like.

Needless to say, a lot of work needs to be done to relate more complex theoretical issues to processing results. One interesting

[23] Quick updates that take place whenever a propositional unit has been parsed might be part of the explanation for the surprising findings in Christianson *et al*. (2001), where subjects are reported to answer 'yes' 60% of the time to the question 'Did Anna dress the baby' after reading the sentence 'While Anna dressed the baby baby spit up on the bed.' This finding suggests that even though subjects revise their syntactic analysis of the garden-path structure, they hold on to the incorrect interpretation (that Anna dressed the baby) corresponding to the initial syntactic analysis of the first part of the sentence.

[24] This is the case, at least, if we assume that the processor makes use of the grammar, as argued above.

question is what happens when a presupposition trigger like *auch* appears early on in a sentence, with the part that satisfies it following later on, as in the following sentence:[25]

(14) Auch der Mann sah die Frau, die
Also the_N man saw $\text{the}_{N/A}$ woman $\text{who}_{N/A}$
das Kind gesehen hatte.
$\text{the}_{N/A}$ child seen had
'Also the man saw the woman that the child had seen.' or
'Also the man saw the woman that had seen the child.'

While it is unclear to me what exactly to expect in connection with this in terms of processing results, it is intuitively clear that there is a certain element of suspense in sentences like this, with a high expectation that the presupposition of *auch* will be satisfied by something that is coming later on in the sentence.

Future work will hopefully be able to address questions related to current issues in the presupposition literature more directly, for example the ever pressing issue of local and global accommodation (see Heim's work and for a recent critical position on local accommodation, van Rooy 1999). If the general approach pursued in this paper is on the right track, local accommodation becomes a very plausible mechanism from the viewpoint of processing. Another important issue, partly related to this, is the question of whether presuppositions are at heart semantic or pragmatic (Stalnaker 1974; Beaver 2001; Simons 2001; Abusch 2005). One might take the apparent automatic nature of presupposition processing to support a semantic view (at least for the presupposition of *also*), but that, of course, depends on how we deal with pragmatic phenomena in processing in general. Without being able to go into the details of these issues, I hope that the present findings will inspire further exploration of these topics from a processing perspective.

4.3 *Implications for processing theories*

Let us now turn to some considerations about what the results reported here mean for a theory of semantic processing. At this point, we are not anywhere close to having a realistic idea of how compositional semantic processing takes place online. One central question, of course, is

[25] Thanks to Francesca Panzeri and Hans Kamp for independently bringing my attention to this question.

at what point the processor actually goes through steps of semantic composition and at what point the content of the currently processed linguistic unit is integrated with the information present in the context (which crucially should involve the evaluation of presuppositions with respect to that context). A viable hypothesis can be constructed from what has been said here: apart from the level of full clauses, where we obviously are dealing with propositional units, updates also take place at the level of noun phrases. This amounts to a straightforward extension of dynamic semantics to the theory of processing. Whether or not this can be upheld, it is the simplest assumption that the processor makes use of the system supplied by the grammar, and it has the advantage of making predictions that should, at least in principle, be experimentally testable. Hopefully, this will also enable us to investigate further theoretical issues in presupposition theory in new ways.

Apart from these issues related immediately to semantic processing, the studies might also contribute to more general architectural questions in processing theory. Let me just mention one particularly interesting point, namely, that the results from the questionnaire study are most likely problematic for a simple version of a parallel parsing architecture along the lines of the one proposed by Crain & Steedman (1985). The idea in this work is that when the processor deals with an ambiguous structure, it considers all possible structures at the same time, with some structures being filtered out by certain principles. One central principle that they assume to account for the data mentioned above in (1) is the principle of parsimony, which only keeps those interpretations that have the fewest presuppositions violated. One of the more intriguing aspects of the questionnaire study discussed here was the interaction of how often subjects would choose the syntactically dispreferred structure (to have the presupposition of *also* satisfied) with the order the clauses appeared in (which affected whether the matrix clause or the relative clause was ambiguous). If people were always considering both interpretations of the ambiguous clauses at the same time, and then choosing one of them based on which one had the fewest presupposition violations, we would expect that they would choose the reading on which the *also* presupposition is satisfied more often than they actually did (in the matrix-first condition with *also*, they chose it only 17% of the time, and even in the relative-first condition, they chose it only 57% of the time). Furthermore, we would not expect that the two clause orders would differ so drastically in this respect. Of course, we need to be cautious in drawing conclusions about online processing from the results of an

offline study. Nonetheless, it is worth considering possible predictions that online accounts make for tasks in offline studies. And unless other factors can be identified that account for the differences between the relative and matrix-first conditions as well as the overall fairly low percentages for the readings where the *also* presupposition is satisfied, these effects are unexpected from the perspective of the framework assumed by Crain & Steedman (1985). Thus, the questionnaire results introduce an interesting question to be considered in this debate between different parsing architectures.

5 CONCLUSION

I have argued that the results from the studies reported here support analyses of additive particles like *also* and *auch* that take into consideration the impossibility of accommodating their presupposition. Furthermore, they suggest that the processor has access to and makes use of presupposed content in online processing and must at least be able to update representations of the context at the level of noun phrases. In a sense, this means taking the 'dynamic' aspect of dynamic semantics quite literally by claiming that the linguistic processor can update representations of the context in the process of interpreting a sentence compositionally. Crucially, the grammar has to provide the means to the processor for accessing the relevant levels of semantic representation at the right time, that is at a time where only parts of sentences, namely the initial noun phrase in the experimental materials, are available.

Bringing our theoretical frameworks and processing theories closer together in this way has the advantage of being temptingly simple. Hopefully, this will lead to interesting new predictions that we can test in further work, and open up the possibility of extending the empirical foundation for work in theoretical semantics and of addressing central issues in presupposition theory that often involve disputes about the intuitive status of presupposed content. Investigating these issues in a more direct empirical way will make an important contribution to the theoretical discussion by providing evidence for the psychological reality of the theoretical notions in question. With a better understanding of what kind of effects related to presuppositions there are in processing, we can hope to address more sophisticated questions in presupposition theory (e.g. the issue of local and global accommodation) by employing psycholinguistic methods to collect empirical evidence.

APPENDIX: MATERIALS

A. Sample of the auch-Questionnaire Materials

1. a/b. Das Marketingteam, das
The$_{N/A}$ marketing-team RP$_{N/A}$
die Abteilungsleiterin beraten hat, hatte
the$_{N/A}$ department-head advised has, had
(auch/vorher) der Geschäftsführer beraten.
also/earlier the$_{N}$ CEO advised.
'The marketing-team that the department head advised, had also been advised by the CEO.' or
'The marketing-team that advised the department-head had also been advised by the CEO.'
Paraphrases to choose from for (a) and (b):

i. Die Abteilungsleiterin wurde
the department-head was
von dem Marketingteam beraten, und das
by the$_{D}$ marketing-team advised and the
Marketingteam von dem Geschäftsführer.
marketing-team by the$_{D}$ CEO
'The department-head was advised by the marketing-team and the marketing-team by the CEO.'

ii. Das Marketingteam wurde von der
the marketing-team was by the$_{D}$
Abteilungsleiterin und vom Geschäftsführer beraten.
department-head and by-the CEO advised
'The marketing-team was advised by the department-head and by the CEO.'

c/d. Das Marketingteam beriet die
The$_{N/A}$ marketing-team advised the$_{N/A}$
Abteilungsleiterin, die
department-head RP$_{N/A}$
(auch/vorher) den Geschäftsführer beraten hatte.
also/earlier the$_{A}$ CEO advised had.
'The marketing-team advised the department-head that also had advised the CEO.' or
'The marketing-team was advised by the department-head that also had advised the CEO.'
Paraphrases to choose from for (c) and (d):

i. Die Abteilungsleiterin wurde von dem
the department-head was by the$_{D}$

Marketingteam beraten und der
marketing-team advised and the
Geschäftsführer von der Abteilungsleiterin.
CEO by the$_D$ department-headi.
'The department-head was advised by the marketing-team and the CEO by the department-head'

ii. Das Marketingteam und der Geschäftsführer wurden
the marketing-team and the$_N$ CEO were
von der Abteilungsleiterin beraten.
by the$_D$ department-head advised
'The marketing-team and the CEO were advised by the department-head'

e. Das Marketingteam beriet die
The$_{N/A}$ marketing-team advised the$_{N/A}$
Abteilungsleiterin, die auch die
department-head RP$_{N/A}$ also, the$_{N/A}$
Geschäftsführerin beraten hatte.
CEO advised had.
Paraphrases to choose from for (e):

i. Die Abteilungsleiterin wurde von
the department-head was by
dem Marketingteam beraten, und die
the$_D$ marketing-team advised and the
Geschäfsführerin von der Abteilungsleiterin.
CEO by the$_D$ department-head
'The department-head was advised by the marketing-team and the CEO by the department-head.'

ii. Die Abteilungsleiterin wurde von dem
the department-head was by the$_D$
Marketingteam und von der
marketing-team und by the$_D$
Geschäftsführerin beraten.
CEO advised
'The department-head was advised by the marketing-team and by the CEO.'

iii. Das Marketingteam und die Geschäftsführerin
the marketing-team and the CEO
wurden von der
were by the$_D$
Abteilungsleiterin beraten.
department-head advised

'The marketing-team and the CEO were advised by the department-head.'

2. a/b. Die Mitarbeiterin, die die Sekretärin
The employee $RP_{N/A}$ the secretary
auswählte, hatte (auch/vorher) der
chose had also/earlier the_N
Direktor ausgewählt.
director chosen

c/d/e. Die Mitarbeiterin wählte die Sekretärin
The employee chose the secretary
aus, die (auch/vorher)
out $RP_{N/A}$ also/earlier
(den/die) Direktor(in) ausgewählt hatte.
the_A/$the_{N/A}$ $director_{(fem)}$ chosen had

3. a/b. Die Spionin, die die Kommissarin verfolgt
The spy $RP_{N/A}$ the superintendent chased
hat, hatte (auch/vorher) der
has had also/earlier the_N
KGB Mann verfolgt.
KGB man chased.

c/d/e. Die Spionin verfolgte die Kommissarin, die (auch/vorher)
(den/die) KGB (Mann/Frau) verfolgt hatte.
The spy chased the superintendent $RP_{N/A}$ also/earlier
the_A/$the_{N/A}$ KGB man/woman chased

4. a/b. Die Grenzbeamtin, die die Polizistin
The border-officer $RP_{N/A}$ the police-officer
kontrollierte, hatte (auch/vorher)
examined had also/earlier
der Staatsanwalt kontrolliert.
the_N prosecutor examined.

c/d/e. Die Grenzbeamtin kontrollierte die Polizistin,
The border-officer examinded the police-officer
die (auch/vorher)
$RP_{N/A}$ also/earlier
(den/die) Staatsanwalt(in) kontrolliert hatte.
the_A/$the_{N/A}$ $prosecutor_{(fem)}$ examinded had

5. a/b. Die Professorengruppe, die das Expertenteam
The group-of-professors $RP_{N/A}$ the expert-team
begutachtete, hatte
reviewed had

(auch/vorher) der Universitätspräsident begutachtet.
also/earlier the_N university-president reviewed.

c/d/e. Die Professorengruppe begutachtete das Expertenteam,
The group-of-professors reviewed the expert-team
das
$RP_{N/A}$
(auch/vorher) (den/die) Universitätspräsidenten(in)
also/earlier $the_A/the_{N/A}$ $university\text{-}president_{(fem)}$
begutachtet hatte.
reviewed had

6. a/b. Die Redakteurin, die das Projektmitglied
The editor $RP_{N/A}$ the project-member
begleitete, hatte
accompanied had
(auch/vorher) der Computertechniker begleitet.
also/earlier the_N computer-technician accompanied

c/d/e. Die Redakteurin begleitete das Projektmitglied,
The editor accompanied the project-member
das (auch/vorher)
$RP_{N/A}$ also/earlier
(den/die) Computertechniker(in) begleitet hatte.
$the_A/the_{N/A}$ $computer\text{-}technician_{(fem)}$ accompanied had

B. Sample of the auch-Self-Paced Reading Materials

1. Das Marketingteam, das (der/den) Manager
$The_{N/A}$ marketing-team $RP_{N/A}$ $the_{N/A}$ manager
beraten hat, hatte
advised has, had
(auch/vorher) der Geschäftsführer beraten.
also the_N CEO advised.
Question: Had the marketing-team advised the manager?

2. Die Spionin,/ die (der/den) Kommissar
the spy $RP_{N/A}$ $the_{N/A}$ super-intendent
verfolgte,/ hatte (auch/vorher) der
chased had also/earlier the_N
KGB-Mann verfolgt.
KGB-man chased
Question: Was the super-intendent chased by the spy?

3. Die Grenzbeamtin,/ die (der/den) Polizist(en)
the border-officer $RP_{N/A}$ $the_{N/A}$ police-officer
kontrollierte,/ hatte
examined had
(auch/vorher) der Staatsanwalt kontrolliert.
also/earlier the_N prosecutor examined
Question: Had the border officer examined the prosecutor?

4. Die Cellistin,/ die (der/den) Komponist(en)
the cellist $RP_{N/A}$ $the_{N/A}$ composer
bewunderte,/ hatte(auch/vorher)
admired had also/earlier
der Dirigent bewundert.
the_N director admired
Question: Was the director admired by the cellist?

5. Die Gruppe,/ die (der/den)
the group $RP_{N/A}$ $the_{N/A}$
Naturschutzverein unterstützte,/ hatte
nature-conversancy-orangisation supported had
(auch/vorher) der Bürgermeister unterstützt.
also/earlier the_N mayor supported
Question: Had the group supported the nature conservancy organisation?

6. Die Norwegerin,/ die (der/den) Finne(n)
the NorwegianFEM $RP_{N/A}$ $the_{N/A}$ Fin
besiegte,/ hatte (auch/vorher) der
defeated had also/earlier the_N
Swede defeated
Schwede besiegt.
Question: Was the Fin defeated by the Norwegian?

C. Sample of the Also Self-Paced Reading Materials

1. The congressman/ who (John) wrote to (John)/ had (also/just) written to the mayor/to schedule a meeting/ for the fundraiser.
2. The electrician/ that (Justin) helps (Justin)/ (also/once) helped the old lawyer/ in setting up/ his new computer.
3. The singer/ who (Josh) met (Josh)/ had (also/once) met Kurt Cobain/ at a benefit concert/ in Boston.

4. The coach/ that (Sam) chose (Sam)/ had (also/almost) chosen a Canadian player/ after the Canadian team/ did so well at the Olympics.
5. The police officer/ who (the burglar) noticed (the burglar)/ had (also/once) noticed a suspicious car/ in front of the building/ on the corner.
6. The model/ that (the producer) spoke with (the producer)/ had (also/recently) spoken with Calvin Klein/ at the show/ in Paris last month.
7. The soccer team/ who (Courtney's school) defeated (Courtney's school)/ (also/recently) beat the state champion/ in the tournament/ last year in Boston.
8. The actor/ that (Shannon) irritated (Shannon) at the party/ had (also/once) annoyed Shannon's Dad/ at the dinner/ the night before.
9. The law professor/ who (the committee) advised (the committee)/ (also/often) coun-seled the governor/ about the education program/ for underprivileged youth.
10. The sports reporter/ that (the sponsor) commended (the sponsor)/ (also/once) praised the tennis player/ for showing up/ despite his injury.
11. The poet/ who (the cellist) admired (the cellist)/ (also/still) looked up to Harvey Keitel/ for his performance/ in Blue in the Face.
12. The agent/ that (the Iranian) was watching (the Iranian)/ (also/still) kept an eye on the shop-owner/ who was suspected of/ dealing with illegal weapons.

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REFERENCES

Abusch, D. (2005), *Triggering from Alternative Sets and Projection of Pragmatic Presuppositions*. Unpublished manuscript, Cornell University.

Bader, M. & M. Meng (1999), 'Subject-object ambiguities in German embedded clauses: an across-the-board comparison'. *Journal of Psycholinguistic Research* **28:**121–43.

Beaver, D. (1997), 'Presupposition'. In J. van Benthem and A. ter Meulen (eds.), *The Handbook of Logic and Language*. Elsevier. Amsterdam. 939–1008.

Beaver, D. (2001), *Presupposition and Assertion in Dynamic Semantics*. CSLI Publications. Stanford, CA.

Beaver, D. & H. Zeevat (2007), 'Accommodation'. In G. Ramchand and C. Reiss (eds.), *Oxford Handbook of Linguistic Interfaces*. Oxford University Press. Cambridge, 503–38.

beim Graben, P., J. D. Saddy, M. Schlesewsky, & J. Kurths (2000), 'Symbolic dynamics of event-related brain potentials'. *Physical Review* **62:**5518–41.

Chambers, C. & V. S. Juan (2005), 'Accommodation and the interpretation of presupposition during referential processing'. Poster presented at the 18th CUNY Conference on Human Sentence Processing. The University of Arizona.

Christianson, K., A. Hollingworth, J. F. Halliwell, & F. Ferreira (2001), 'Thematic-roles assigned along the garden path linger'. *Cognitive Psychology* **42:**368–407.

Crain, S. & M. Steedman (1985), 'On not being led up the garden path: the use of context by the psychological parser'. In D. R. Dowty, L. Karttunen, and A. Zwicky (eds.), *Natural Language Parsing: Psychological, Computational, and Theoretical Perspectives*. Cambridge University Press. Cambridge. 320–58.

Frazier, L. (2006), *The Big Fish in a Small Pond: Accommodation and the Processing of Novel Definites*. Unpublished manuscript, University of Massachusetts Amherst.

Geurts, B. (1999), *Presuppositions and Pronouns*. Elsevier. Amsterdam, New York. [Includes bibliographical references ([223]–9) and indexes].

Heim, I. (1982), *The Semantics of Definite and Indefinite Noun Phrases*. Ph.D. thesis, University of Massachusetts. Amherst, MA.

Heim, I. (1983a), 'File change semantics and the familiarity theory of definiteness'. In R. Baeuerle, R. Schwarze, and A. von Stechow (eds.), *Meaning,*

Use, and Interpretation of Language. De Gruyter. Berlin. 164–89.

Heim, I. (1983b), 'On the projection problem for presuppositions', In D. Flickinger, *et al*. (eds.), *Proceedings of the Second West Coast Conference on Formal Linguistics*. Stanford University. 114–25.

Heim, I. (1992), 'Presupposition projection and the semantics of attitude verbs'. *Journal of Semantics* **9:**183–221.

Hemforth, B. (1993), *Kognitives Parsing: Repräsentation und Verarbeitung grammatischen Wissens*. Infix. Sankt Augustin.

Kamp, H. (1981), 'A theory of truth and semantic representation'. In J. Groenendijk, T. Janssen, and M. Stokhof (eds.), *Formal Methods in the Study of Language: Proceedings of the Third Amsterdam Colloquium*, vol. I. Mathematical Center. Amsterdam. 227–321.

Kamp, H. & U. Reyle (1993), *From Discourse to Logic*. Kluwer. Dordrecht.

Karttunen, L. (1973), 'Presuppositions of compound sentences'. *Linguistic Inquiry* **4:**169–93.

Karttunen, L. (1974), 'Presupposition and linguistic context'. *Theoretical Linguistics* **1:**181–94.

Karttunen, L. & S. Peters (1979), 'Conventional implicature'. *Syntax and Semantics 11: Presupposition*. Academic Press. New York. 1–56.

Kim, A. & L. Osterhout (2005), 'The independence of combinatory semantic processing: evidence from event-related potentials'. *Journal of Memory and Language* **52:**205–25.

Krifka, M. (1999), 'Additive particles under stress'. In *SALT*. CLC Publications. Ithaca, NY. 111–28.

Kripke, S. (1991), *Presupposition and Anaphora: Remarks on the Formulation of the Projection Problem*. Unpublished manuscript, Princeton University.

Lewis, D. (1979), 'Scorekeeping in a language game'. In R. Baeuerle, U. Egli, and A. von Stechow (eds.), *Semantics from Different Points of View*. Springer. Berlin. 172–87.

Noveck, I. & D. Sperber (eds.) (2004), *Experimental Pragmatics*. Palgrave Macmillan. Basingstoke.

Schlesewsky, M. & A. Friederici (2003), 'Sentence processing mechanisms'. In L. Nadel (ed.), *Encyclopedia of Cognitive Science*. Macmillan Reference. London. 1149–55.

Schlesewsky, M., G. Fanselow, R. Kliegl, & J. Krems (2000), 'The subject-preference in the processing of locally ambiguous wh-questions in german'. In B. Hemforth and L. Konieczny (eds.), *German Sentence Processing*. Kluwer. Dordrecht. 65–93.

Schwarz, F. (2006), 'Presuppositions in Processing—a case study of German *auch*'. In C. Ebert and C. Endriss (eds.), *Proceedings of Sinn und Bedeutung 10*. ZAS. Berlin. 301–15.

Simons, M. (2001), 'On the conversational basis of some presuppositions'. In R. Hastings, B. Jackson and Z. Zvolensky (eds.), *Proceedings of Semantics and Linguistic Theory 11*. CLC Publications. Ithaca, NY. 427–46.

Spenader, J. (2002), *Presuppositions in Spoken Discourse*. Ph.D. thesis, Computational Linguistics, University of Stockholm.

Stalnaker, R. (1973), 'Presuppositions'. *Journal of Philosophical Logic* **2:** 447–57.

Stalnaker, R. (1974), 'Pragmatic presuppositions'. In M. Munitz and P. Unger (eds.), *Semantics and Philosophy*. New York University Press. New York. 197–214.

van Berkum, J. J. A., C. M. Brown, & P. Hagoort (1999), 'Early referential context effects in sentence processing:

evidence from event-related brain potentials'. *Journal of Memory and Language* **41:**147–82.

van Berkum, J. J. A., C. M. Brown, P. Hagoort, & P. Zwitserlood (2003), 'Event-related brain potentials reflect discourse-referential ambiguity in spoken language comprehension'. *Psychophysiology* **40:**235–48.

van der Sandt, R. (1988), *Context and Presupposition*. Croom Helm. London.

van der Sandt, R. & B. Geurts (2001), 'Too', In P. Dekker and R. van Rooy (eds.), *13th Amsterdam Colloquium*. 180–5.

van der Sandt, R. A. (1992), 'Presupposition projection as anaphora resolution'. *Journal of Semantics* **9:**333–77.

van Rooy, R. (1999), 'Against local accommodation'. In M. K. Bart Geurts and R. van der Sandt (eds.), *Focus and Presupposition in Multi-speaker Discourse. Workshop held at the 11th European Summer School in Logic, Language, and Information*. ESSLI. Amsterdam.

von Fintel, K. (2004), 'Would you believe it? The king of France is back! (presuppositions and truth-value intuitions)'. In M. Reimer and A. Bezuidenhout (eds.), *Descriptions and Beyond*. Oxford University Press. Oxford. 315–41.

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