Presupposition*

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1 Introduction

In conversation, much is presupposed, or taken for granted. The linguistic and philosophical theories which will be discussed in this chapter vary in the extent to which they involve definitions of presupposition which are close to this informal use of the word, and there is no single technical definition of *presupposition* which will satisfy all theorists.[1]

A particular point of dispute has been whether presupposition is best thought of as a semantic or a pragmatic notion, or whether indeed such notions must coexist. In a semantic theory presupposition is usually defined as a binary relation between pairs of sentences of a language. What makes this relation semantical is that it is defined or explicated in terms of the semantic valuation of the sentences, or in terms of a semantic notion of entailment. Thus a definition in terms of semantic valuation might, following Strawson, say that one sentence (semantically) presupposes another if the truth of the second is a condition for the semantic value of the first to be *true* or *false*. In pragmatic theories the analysis of presupposition involves the attitudes and knowledge of language users. In extreme cases such as Stalnaker's [St74] account, presupposition is defined without any reference to linguistic form: Stalnaker talks not of the presuppositions of a sentence, but of the *speaker's presuppositions*, these being just those propositions which are taken for granted by a speaker on a given occasion. Other pragmatic theories are less radical, in that linguistic form still plays an essential role in the theory. The majority of well-developed pragmatic theories concern the presuppositions not of a sentence (as in semantic theories) or of a speaker (as in Stalnaker's theory) but of an utterance.

In the late seventies the lack of an agreed definition was a subject of much debate, and perceived by some as a stumbling block preventing further progress in the field. However, since then there has been much progress (even without an agreed definition) as should become clear in the coming sections. The semantic/pragmatic debate is little aired nowadays, since so many researchers espouse hybrid theories on which the labels *semantic* and *pragmatic* are hard to pin.

What the different theories that have been proposed over the years have in common is not a single notion of presupposition, but a more or less accepted set of basic data to be explained, and a more or less accepted set of linguistic constructions to which this data pertains. The data includes such tired examples as 'Have you stopped beating your wife?' and 'The King of France is not bald.', in which the relevant constructions, or *presupposition triggers*, include the aspectual verb 'stop', the possesive 'your' and the definite 'the'.

With regard to the first example, one may say that the proposition that the addressee has beaten his wife is given a special status. Similarly, many theorists would argue that the proposition that there is a King of France has a special status in the second example. Perhaps such propositions are taken for granted. Perhaps they are propositions that must be true for utterances of the examples to carry meaning. Perhaps they are both. Whilst there is no agreed technical definition of *presupposition*, there is agreement that the goals of presupposition theory must include determining the special status of such propositions, and explaining why and under what conditions this status obtains.

In the remainder of §1 some further basics are discussed, and the foundations are laid for

[1] On a historical note, there is disagreement as to the first use of a technical notion of presupposition. Seuren [Seu94a] notes that a well known paradox offered by Aristotle's contemporary, Eubulides of Miletus, the so-called *Paradox of the Horned Man*, is based on a presuppositional effect. Caffi [Ca94], writing in the same volume as Seuren, traces presupposition "back to Xenophanes, quoted in Aristotle's *Rhetoric* . . . , via Port Royal . . . and John Stuart Mill." Despite these mentions of Aristotle, and despite the very, very, very long running debate as to whether Aristotle favoured a departure from bivalence, the following is an example of Aristotle expounding a view that runs contrary to any semantic notion of presupposition: "For manifestly, if Socrates exists, one of the two propositions 'Socrates is ill', 'Socrates is not ill' is true, and the other false. This is likewise the case if he does not exist; for if he does not exist, to say that he is ill is false, and to say that he is not ill is true." (From Aristotle's *Categories* [Ar50, Ch.10:13b pp. 27-35].) Larry Horn provided me with a convincing reference to an invocation of a concept of presupposition by a medieval scholar. See the passage around line 100 of Petrus Hispanus' *Tractatus Exponibilium*, in [Mul45]: "Prima est quod diction reduplicativa *praesupponit* aliquod praedicatum iness aliqui subiecto et denotat quod illud super quod adit immediate sit causa inhaerentiae illius." [My emphasis.] The recent philosophical study of presupposition is generally recognised to have started with Frege's remarks in *On Sense and Meaning* [Fr84b], which are not explicitly related to the work of any predecessor.

the presentation of different accounts. Then we dive head-first into the depths of presupposition theory. One of the main insights of the last few decades of study of presupposition is that the phenomenon is heavily influenced by the dynamics of the interpretation process. Therefore, I have divided systems according to the way in which such dynamism is manifested. §2 "Static Accounts: Multivalence and Partiality" concerns models in which the dynamics of the interpretation process plays no role, and where the possibility of presupposition failure is tied to the presence of extra truth values in a multivalent (or partial) semantics. In §3: "Context Dependence and Part-Time Presupposition" models are presented in which the context of evaluation influences which presuppositions are projected, models involving an *inter-sentential dynamics* where the context of evaluation is modified with each successive utterance. In §4 "Context Change and Accommodation" theories are discussed in which *intra-sentential dynamics* plays a crucial role, with sub-sentential constituents being seen as having there own dynamic effects on the context of evaluation used for other constituents, and a process of accommodation allowing presuppositions themselves to produce sophisticated additional modifications. In writing this chapter I have tried to bring out the relationships between different theories, and §5 "Syntheses" is devoted entirely to this goal. §6 "Empirical Issues" rounds off the chapter with a more data-driven comparison of theories.[2]

1.1 The Presupposition Triggers

The class of English presuppositional constructions is commonly depicted as including those in the following list. Note that the references given include authors who would not agree with the presuppositional classification.

Definite NPs The main references for the famous Russell-Strawson debate which centred on whether definites should be seen as presuppositional are [St50, St64, Ru05, Ru57]. The literature is enormous, but see e.g. the following selection: [Haw76, CM81, Ei93, Hei82, Kad90, Ne90]. The class of definites may be taken to include proper names, possessives, 'this'- and 'that'-clauses, and wh-phrases (some of which could alternatively be thought of as embedded questions, and are often analysed as having category other than NP).

Quantificational NPs presupposing existence of a non-trivial quantificational domain. See e.g. [dJV87, LR88, vF94], or e.g. [Ber81] for an example of a formal system where such presuppositions are built in.

Factive verbs and NPs presupposing truth of the propositional complement. E.g. 'regret', 'know', 'the fact that X' and 'the knowledge that X'. There is a large literature on factives, starting with the Kiparskys' landmark [KK70]. There has been much discussion as to whether *cognitive factives* (which concern knowledge of facts) and *emotive factives* (which concern emotional attitudes towards facts) manifest different presuppositional behaviour, as first suggested by Karttunen [Kar71a]. See e.g. [Kl75, Gaz79a, St74]. Other work on factives includes e.g. [Po72, Zu77, Pe79].

Clefts An it-cleft 'it was x that y-ed' is argued to presuppose that something 'y-ed'. Similarly for wh- and pseudo-clefts. See e.g. [PriMS, Deli90, Deli92, Ra92].

Wh-questions presuppose existence of an entity answering the question, or speakers expectation of such an entity. See e.g. [Bel69, PriMS] and Groenendijk and Stokhof's chapter on questions in this volume.

[2]The reader is also pointed to a number of excellent previous surveys: Levinson [Le83] provides a gentle introduction to the important issues. Soames [So89] has provided an excellent overview article, whilst van der Sandt's discussion in [vdS88, pp.1–154] is not only insightful but also has been unsurpassed for breadth of coverage. More recently some shorter overview articles have appeared, by Horn [Horn94, Horn95] and Seuren [Seu91], as well as the collection of encyclopedia entries [Ca94, Seu94a, Seu94b, Seu94b]. Contemporary PhD theses are of course a mine of information: see for instance the literature overviews in Bridges' [Br91] and Marcu's [Ma94], both of which are strong concerning more computationally oriented accounts of presupposition, and especially Geurts' [Geu95] and Schöter's [Schö:MS].

Counterfactual conditionals , presupposing falsity of the antecedent. See [Kar71c], the discussion of subjunctives in [Kas92], and the arguments against there being a presupposition in [KP79].

Intonational Stress . Destressed or unstressed material is sometimes thought to induce a presupposition, so that e.g. 'X y-ed' with stressed 'X' might presuppose that somebody 'y-ed'). See e.g. [Hal67, Cho??, PriMS, Rein82, SHB73, Sg:MS, Horn86, Blo93, GP90, Roo95].

Sortally restricted predicates presuppose rather than assert that their arguments are of the appropriate sort. E.g. 'dream' presupposes animacy of its subject, and predicative use of 'a bachelor' presupposes that the predicated individual is adult and male. Also sometimes referred to as *categorical* restrictions. See e.g. [Fi71a, Seu88].

Signifiers of actions and temporal/aspectual modifiers Most verbs signifying actions carry presuppositions that the preconditions for the action are met. These could be conceived of as a special case of sortal restriction. Modifiers such as the verbs 'stop' and 'continue', and the adverbs such as 'still' are discussed more often in the literature: all of them can be seen as placing presuppositional requirements on the initial state. The modifiers may be clausal, as in 'before' and 'after' clauses. See [Au93, Lor92, Hein72, Meu:MS]

Iterative Adverbs such as 'too' and 'again' are said to presuppose some sort of repetition. These are discussed e.g. in [Krip:MS, Ze94, KRo94, Ros94]. Iteratives occur in other syntactic classes (e.g. the determiner 'another', and, relatedly, the noun modifier 'other'), and may even be seen as extending below the lexical level to the morpheme 're-'.

Others Various other presupposition triggers have been identified, for instance Karttunen's *implicatives* [Kar71b] (e.g. 'manage','succeed'), Fillmore's *verbs of judging* (e.g. 'criticise') [Fi71b], the *focus-sensitive* particles 'even' and 'only' [Ho69, Krif92], discourse connectives such as 'although' and 'because' [LO94], non-restrictive relative clauses (which pass the negation test, yet are invariably used to convey new information) and Keenan's pragmatic felicity conditions (e.g. use of polite forms) [Kee71].

1.2 Projection/Heritability

Frege's 1 [Fr84a] has 2 as one of its implications, but it is no surprise, given some knowledge of classical logic, that 2 does not follow from any of 3–5, in which 1 is embedded under negation, in the antecedent of a conditional and within a modal possibility operator respectively.

(1) Whoever discovered the elliptic form of the planetary orbits died in misery.

(2) Somebody died in misery.

(3) Whoever discovered the elliptic form of the planetary orbits did not die in misery.

(4) If whoever discovered the elliptic form of the planetary orbits died in misery, he should have kept his mouth shut.

(5) Perhaps whoever discovered the elliptic form of the planetary orbits died in misery.

However, consider 6, which Frege claims to be presupposed by 1. Strikingly, 6 seems to be implied by 1, but also by all of 3–5. We may say that one implication of 1 is *inherited* or *projected* such that it also becomes an implication carried by the complex sentences in 3–5, whereas another implication of 1 is not inherited in this way.

(6) Somebody discovered the elliptic form of the planetary orbits.

This takes us to the curse and the blessing of modern presupposition theory. Certain implications of sentences are inherited more freely to become implications of complex sentences containing the simple sentences than are other implications, and such implications are commonly called presuppositions. In its guise as curse this observation is called (following Langendoen and Savin *the presupposition projection problem*, the question of "how the presupposition and assertion of a complex sentence are related to the presupposition and assertions of the clauses it contains"[LS71, p.54]. The problem can be seen as twofold. Firstly we must say exactly what presuppositions are inherited, and secondly we must say why. But the observation is also a blessing, because it provides an objective basis for the claim that there is a distinct presuppositional component to meaning, and a way of identifying presuppositional constructions, a linguistic test for presupposition on a methodological par with, for instance, standard linguistic constituency tests.

To find the presuppositions of a given grammatical construction or lexical item, one must observe which implications of simple sentences are also implications of sentences in which the simple sentence is embedded under negation, under an operator of modal possibility or in the antecedent of a conditional. To be sure, there is nothing sacred about this list of embeddings from which presuppositions tend to be projected, and the list is certainly not exhaustive. The linguist might equally well choose to consider different connectives, or non-assertive speech acts, as with the question in 7 or the imperative in 8.[3]

(7) Did whoever discovered the elliptic form of the planetary orbits die in misery?

(8) Ensure that whoever discovered the elliptic form of the planetary orbits dies in misery!

Returning to projection *qua* problem rather than *qua* test, it is often forgotten that, from a semantic perspective, the projection problem for presuppositions fits quite naturally into a larger Fregean picture of how language should be analysed. The projection problem for presuppositions is the task of stating and explaining the presuppositions of complex sentences in terms of the presuppositions of their parts. The larger problem, which strictly contains the presupposition projection problem, could naturally be called "the projection problem for meanings", i.e. the problem of finding the meanings of complex sentences in terms of the meanings of their parts. Of course, this larger problem is conventionally referred to under the general heading of *compositionality* (for discussion of which, see Janssen's chapter in this volume.)

1.3 From Projection Data to Theories of Projection

Much research on presupposition to date, especially formal and semi-formal work, has concentrated on the projection problem. This article reflects that bias, and is concerned primarily with formal models of presupposition projection. Other important issues, such as the nature of presupposition itself, the reasons for there being presuppositions in language, and the place of presuppositions within lexical semantics, are addressed here only insofar as they are relevant to distinguishing alternative projection theories. To facilitate comparison, I will present most theories in terms of an artificial language, what I will call the language of *Presupposition Logic* (henceforth *PrL*). This is just the language of Propositional Logic (*PL*) with an additional binary operator notated by subscripting: a formula ϕ_ψ should be thought of as 'the assertion of ϕ carrying the presupposition that ϕ'.[4] I will occasionally delve into modal and first order variants of PrL, and also into a presuppositional version of Discourse Representation Theory.

[3] Questions have been considered as test-embeddings for presuppositions by Karttunen. The behaviour of presuppositions in imperatives is discussed by Searle [Sea:69, p. 162]. Burton-Roberts suggests the following generalization of the standard negation test for presuppositions: "Any formula equivalent to a formula that entails either p or its negation, and the negation of any such formula, will inherit the presuppositions of p."[Bu89b, p.102] Such a generalization seems problematic. For if we allow that a contradiction entails any sentence, then it follows that a contradiction presupposes everything. But any tautology is standardly equivalent to the negation of a contradiction, so all tautologies must presuppose everything. Further, if a tautology is entailed by any other sentence, it immediately follows that every pair of sentences stands in the relation of presupposition. I fear Burton-Roberts presupposes too much.

[4] Elsewhere (see e.g. [Bea95]) I have preferred to use a unary presupposition connective. For most of the systems to be presented, this is not significant, since the relevant unary and binary connectives are interdefineable. Krahmer

Translations will be very schematic. For instance, 'The King of France is bald' will be analysed as if it had the form ϕ_ψ, with ψ being understood as the proposition that there is a unique French King and ψ being understood as a (bivalent) proposition to the effect that there is a bald French King. I do not wish to claim that ϕ_ψ is a good translation of 'The King of France is bald', or even that it is in general possible to isolate the presupposition of a given construction (here given as ψ) from the assertion (here ϕ): some theories do make such an assumption, and others do not. I only claim that the way in which the theories (as I will present them) treat my translations provides a fair characterisation of how the theories (as originally presented) would handle the corresponding English examples.

There are two main sources of data to use as desiderata when comparing theories of presupposition: felicity judgements, and implications between sentences. The standard tests for presupposition are, as I have said, based on the latter. To use felicity judgements, one requires a theory which divides sentences (or discourses) into good and bad, just as a generative grammar does. But theories of presupposition tend not to make such an explicit division.[5] Thus the principal goal of a theory will be seen as the formalisation of a notion of implication (entailment/necessitation/consequence) between formulae of PrL which takes presuppositional implications into account. In some cases felicity judgements can act as desiderata within this framework, if it is supposed that the reason for a discourse's infelicity is that it implies things which hearers have difficulty accepting.

This notion of implication will be denoted $\Vdash$ to distinguish it from classical entailment $\models$. The presuppositionally sensitive implication relation $\Vdash$ should be expected to be weaker than $\models$, in the sense that there will be more $\Vdash$-valid inference patterns than $\models$-valid ones. A proposition may be $\Vdash$-implied if it follows either as a result of classically recognised patterns of reasoning, or as a result of reasoning connected to presupposition, or indeed as a result of some combination of these. Thus, for instance, we may record the fact that the presupposition of a simple negative sentence projects in the absence of extra context in terms of the following datum: $\neg(\phi_\psi)\Vdash\psi$, where ϕ and ψ are taken to be logically independent (i.e. $\phi\not\Vdash\psi$ and $\psi\not\Vdash\phi$). Although theories of presupposition can generally be formulated in terms of a $\Vdash$ relation with little or no loss of descriptive adequacy, many theorists have preferred to divorce presupposition from semantic entailment. So for various systems a relation of presupposition between sentences, denoted by $\gg$, will be directly defined. For these systems one could of course define $\Vdash$ in terms of $\models$ and $\gg$, perhaps most obviously (under a restriction to single premise, single conclusion implications) by: $\Vdash = (\models \cup \gg)^\star$ (i.e. the relation $\Vdash$ is the closure under iteration of the relations $\models$ and $\gg$). [6]

2 Static Accounts: Multivalence and Partiality

If the accounts to be discussed in this section differ as to the precise refinement from classical interpretation which they utilise, they none the less share a basic approach to presupposition projection: (1) Presuppositions are constraints on the range of worlds/models against which we are able to evaluate the truth or falsity of predications and other semantic operations, or against which this evaluation is legitimate. (2) If these constraints are not met, semantic undefinedness, or illegitimacy of the truth-value, results. (3) Presupposition projection facts associated with a given operator are explained in terms of the relation between the definedness/legitimacy of that

[Krah:MS] has used a binary presupposition connective with the notation adopted here, and in the case of trivalent logics the semantics to be given for that connective coincides with Blamey's *transplication* [Blam89].

[5] One exception is the theory developed in van der Sandt's doctoral thesis [vdS82, vdS88, vdS89].

[6] Some might maintain that presuppositional inferences are of a quite different character to the 'ordinary' truth-functional implications formalised in classical logic, but I do not take this to be an argument against presenting the goal of presupposition theory in similar terms as might used to state the goal of classical logic. '$\Vdash$' is just a relation between sentences (or sets of sentences), regardless of the extent to which it depends on the familiar paraphernalia of classical logic (semantic valuations, axiomatisation, etc.). In some theories, presuppositions of a sentence are analysed relative to a context. But in all of the theories that will be discussed, this context is itself linguistically supplied, and could be thought of as consisting of just the sequence of sentences Σ which are extra premises in an argument of the form $\Sigma, \phi\Vdash\psi$.

operator and the definedness/legitimacy of its arguments.[7]

In what follows I will firstly consider truth-functional partial and trivalent systems (those which may be given in terms of truth tables), then a non-truth-functional supervaluation system, and finally the two-dimensional approach (which effectively uses four values). [8]

2.1 Trivalent Accounts

In a trivalent logic, where the semantic valuation of a formula ϕ with respect to a world w (here written $[\![\phi]\!]_w$) may take any of the three semantic values, typically thought of as true, false and undefined $(t, f, \star)$, presupposition may be defined as follows:

Definition 1 (Strawsonian Presupposition) *ϕ presupposes ψ iff for for all worlds w, if $[\![\phi]\!]_w \in \{t, f\}$ then $[\![\psi]\!]_w = t$.*

A model here, and for most of this chapter, is taken to be a pair $\langle W, I\rangle$ where W is a set of worlds, and I is an interpretation function mapping a pair of a world and an atomic proposition letter to an element of $\{t, f\}$. Let us assume, a Tarskian notion of logical consequence as preservation of truth ($\phi \models \psi$ iff for all worlds w, if $[\![\phi]\!]_w = t$ then $[\![\psi]\!]_w = t$) Let us further assume that a negation $\neg$ is available in the formal language which is interpreted classically with respect to classically valued argument formulae, mapping true to false and *vice versa*, but which preserves undefinedness. This defines a so-called *choice* negation (as in 4 below). Given these notions of consequence and negation, it is easily shown that the above definition of presupposition is equivalent to the following:

Definition 2 (Presupposition Via Negation) *ϕ presupposes ψ iff $\phi \models \psi$ and $\neg\phi \models \psi$*

These, then, are the standard approaches to defining presupposition in three-valued logics. One author who offers a significant deviation from these definitions is Burton-Roberts [Bu89a]. He defines two separate notions of logical consequence, *weak* consequence, which is just the notion $\models$ above, and *strong* consequence, which is closer to classical implication than $\models$ (e.g. no non-trivial formulae are strongly entailed by both a formula and its negation). For one proposition to strongly entail another, the truth of the first must guarantee the truth of the second, and the falsity of the second must guarantee the falsity of the first. Let us denote strong consequence by $\models_s$,

[7] In this section I have concentrated on the traditional static departures from boolean interpretation. Recently a number of other systems which involve non-standard static logical systems have been proposed, although the application of these systems to natural language is in many ways informed by the dynamic systems of §4, below. I am thinking of the proposals to deal with presupposition in *property theory* [Ra92, Fo:MS], constructive type theory [Krau95], and also of situation theory. But note that whilst situation theorists have used partial semantics to deal with presuppositional phenomena such as definites, quantifier domain restriction and questions (see e.g. [GP90, Co92, Gi95]), there is, to my knowledge, not yet any proposal in situation theory which has been proffered as a theory of presupposition *per se*.

[8] I was once horrified to hear a group of presupposition theorists arguing bitterly about whether the treatment of presupposition should use a partial or a trivalent logic. There may be philosophical significance to the choice between partial and trivalent systems, and it may be that there are applications (like the treatment of the semantical paradoxes) where it really makes a difference whether the semantical universe contains only two values for the extension of a proposition or is in some way richer. But it seems unlikely that the decision to use a partial or trivalent logic has significant empirical consequences regarding presupposition projection. In general, relevant aspects of a model of presupposition projection presented in terms of either a trivalent logic or a partial logic are straightforwardly reformulable in terms of the other with no consequences for the treatment of presupposition data. I will collapse the terms *trivalent* and *partial*: the symbol $\star$ may be understood either as a third truth value, or as a failure to define a truth value. In so doing I assume what I take to be the conventional use of the term *partial logic* by logicians (see e.g. [Blam89]), whereby, for instance, versions of both Kleene's strong and weak systems are sometimes referred to as partial logics. Seuren [Seu85, Seu90a] offers an alternative characterisation whereby only Kleene's weak system (Bochvar's internal system) would count as a gapped/partial logic. This is because he implicitly limits consideration to systems which are truth functional in a strong sense, such that a compound formula can only have a value defined if the valuation of all the arguments is defined. On the other hand, Burton-Roberts [Bu89a] offers a system which he claims to have the only *true* gapped bivalent semantics, and which just happens to contain exactly the connectives in Kleene's strong system! Given a lack of consensus among such forceful rhetoricians as Seuren and Burton-Roberts, it is perhaps unwise to stick one's neck out.

where: $\phi \models_s \psi$ iff (1) $\phi \| \models \psi$, and (2) for all worlds w, if $[\![\psi]\!]_w = f$ then $[\![\phi]\!]_w = f$.[9] Burton-Roberts then suggests that presuppositions are weak consequences which are not strong consequences:

Definition 3 (Burton-Roberts Presupposition) *ϕ presupposes ψ iff $\phi \| \models \psi$ and $\phi \not\models_s \psi$*

This seems an attractive definition, and is certainly not equivalent to the standard definitions above. However, it has some rather odd properties. For example, assuming this definition of presupposition and Burton-Roberts' quite standard notion of conjunction, it turns out that if ϕ presupposes ψ, then ϕ presupposes $\psi \wedge \phi$. Let us assume that 'The King of France is bald' presupposes 'There is a King of France'. According to Burton-Roberts' definition it must also presuppose 'There is a King of France and he is bald', which seems completely unintuitive. More generally, if ϕ presupposes ψ then according to this definition it must also presuppose the conjunction of ψ with *any* strong consequence of ϕ.[10] I see no reason why we should accept a definition of presupposition with this property.

Moving back to the standard definitions, the presupposition projection behaviour of various three-valued logics will now be examined. A simple picture of presupposition projection is what is known as the *cumulative hypothesis* (c.f. Langendoen and Savin [LS71]) according to which the set of presuppositions of a complex sentence consists of every single elementary presupposition belonging to any subsentence. As far as the projection behaviour of the logical connectives is concerned, such a theory of projection would be modeled by a trivalent logic in which if any of the arguments of a connective has the value $\star$, then the value of the whole is also $\star$. Assuming that combinations of classical values are still to yield their classical result, this yields the so-called *internal Bochvar* or *weak Kleene* connectives [Boc38, Kl38]:

Definition 4 (The Weak Kleene or Internal Bochvar Connectives)

$\phi \wedge \psi$	t	f	$\star$
t	t	f	$\star$
f	f	f	$\star$
$\star$	$\star$	$\star$	$\star$

$\phi \rightarrow \psi$	t	f	$\star$
t	t	f	$\star$
f	t	t	$\star$
$\star$	$\star$	$\star$	$\star$

$\phi \vee \psi$	t	f	$\star$
t	t	t	$\star$
f	t	f	$\star$
$\star$	$\star$	$\star$	$\star$

ϕ	$\neg\phi$
t	f
f	t
$\star$	$\star$

[9] Wilson [Wi75] took a definition of consequence like $\models$ as fundamental, and used it as part of her argument against semantic theories of presupposition. In a more technically rigorous discussion, Blamey [Blam89] also suggests that the strong notion should be the basic one.

[10] Burton-Robert's system uses Kleene's strong *falsity preserving* conjunction, whereby a conjunction is true if and only if both conjuncts are true, and false if and only if at least one conjunct is false. The following argument then shows that a proposition must presuppose any conjunction of a presupposition and a strong entailment:

1. Suppose ϕ presupposes ψ in Burton-Roberts system
2. Then (a) $\phi \| \models \psi$, and (b) $\phi \not\models_s \psi$
3. From ii, $[\![\psi]\!]_w = f$ and $[\![\phi]\!]_w \neq f$ for some world w
4. Suppose $\phi \models_s \chi$
5. By definition of $\models$, we have that $\phi \| \models \chi$
6. By iib, v and definitions of $\wedge, \|\models$, it follows that $\phi \| \models \psi \wedge \chi$
7. Relative to the same model M, where ψ is false, falsity preservation of $\wedge$ tells us that $\psi \wedge \chi$ is false
8. Since there is a model (M) where ϕ is not false and its weak entailment $\psi \wedge \chi$ is false, it follows that $\phi \not\models_s \psi \wedge \chi$
9. Hence ϕ must presuppose $\psi \wedge \chi$ in Burton-Roberts system. □

It should be mentioned that the above is not the only definition of presupposition that Burton-Roberts offers: it seems to be intended as a definition of the elementary presuppositions of a simple positive sentence. Presuppositions of compound sentences are given by a relation of *Generalised Presupposition*. This notion, which will not be discussed in detail here, is essentially the same as a notion of presupposition used earlier by Hausser [Hau76]. It says that one formula presupposes another if falsity of the second creates the possibility of undefinedness for the first.

A naive version of the cumulative hypothesis, such as is embodied in the definition of Bochvar's internal connectives, is not tenable, in that there are many examples of presuppositions not being projected. Let us consider firstly how this is dealt with in the case that has generated the most controversy over the years, that of negation.[11] In a trivalent semantics, the existence of cases where presuppositions of sentences embedded under a negation are not projected, is normally explained in terms of the existence of a *denial* operator (here $\sharp$) such that when $[\![\phi]\!]_w = \star$, $[\![\sharp\phi]\!]_w = t$. Typically the following *exclusion* (sometimes called *weak*) negation operator results:

Definition 5 (Trivalent Exclusion Negation)

ϕ	$\sharp\phi$
t	f
f	t
$\star$	t

Since there apparently exist both cases where a negation acts, in Karttunen's terminology, as a *hole* to presuppositions (allowing projection) and cases where it acts as what Karttunen called a *plug* (preventing projection), the defender of a trivalent account of presupposition appears not to have the luxury of choosing between the two negations given above, but seems forced to postulate that negation in natural language is ambiguous between them. Unfortunately, convincing independent evidence for such an ambiguity is lacking, although there may at least be intonational features which mark occurrences of denial negation from other uses, and thus potentially allow the development of a theory as to which of the two meanings a given occurrence of negation corresponds.[12]

There is a frequently overlooked alternative to postulating a lexical ambiguity, dating back as far as Bochvar's original papers. Bochvar suggested that apart from the normal mode of assertion there was a second mode which we might term *meta-assertion*. The meta-assertion of ϕ, $A\phi$, is the proposition that ϕ is true: $[\![A\phi]\!]_w = t$ if $[\![\phi]\!]_w = t$ and $[\![A\phi]\!]_w = f$ otherwise. Bochvar showed how within the combined system consisting of the internal connectives and this assertion operator a second set of *external* connectives could be defined: for instance the external conjunction of two formulae is just the internal conjunction of the meta-assertion of the two formulae (i.e. $\phi \wedge_{\text{ext}} \psi =_{\text{def}} A(\phi) \wedge_{\text{int}} A(\psi)$), and the external negation of a formula is just the exclusion negation given above, and defined in the extended Bochvar system by $\sharp\phi =_{\text{def}} \neg A(\phi)$. Thus whilst the possibility of declaring natural language negation to be ambiguous between $\neg$ and $\sharp$ exists within Bochvar's extended system, another possibility would be to translate natural language negation uniformly using $\neg$, but then allow that sometimes the proposition under the negation is itself clad in the meta-assertoric armour of the A-operator.

There is no technical reason why the Bochvarian meta-assertion operator should be restricted in its occurrence to propositions directly under a negation. Link [Li86] has proposed a model in which in principle any presupposition can be *co-asserted*, where coassertion, if I understand correctly, essentially amounts to embedding under the A-operator. Such a theory is flexible, since it leaves the same logical possibilities open as in a system with an enormous multiplicity of connectives. Link indicates that pragmatic factors will induce an ordering over the various readings, although

[11] Horn's article [Horn85]) provides an excellent overview of treatments of negation and considers cases of presupposition denial at length. For a longer read, his [Horn89] is recommended. Extensive discussion of negation within the context of contemporary trivalent accounts of presupposition is found in the work of Seuren [Seu85, Seu88], and Burton-Roberts [Bu89c, Bu89a]. Burton-Roberts publications sparked considerable controversy, to a degree surprising given that Burton-Roberts, though innovative, presents what is essentially a reworking of the quite well worn trivalent approach to presupposition. The refreshingly vehement debate provides the definitive modern statements of the alternative positions on negation within trivalent systems: see Horn's [Horn90] and Burton-Roberts' reply [Bu89b], Seuren's [Seu90a] and Burton-Roberts' reply [Bu90], and Seuren and Turner's reviews [Seu90b, Tu92].

[12] If the *raison d'etre* of a trivalent denial operator is to be yield truth when predicated of a non-true and non-false proposition, then in principle some choice remains as to how it should behave when predicated of a simply false proposition. Thus the denial operator need not necessarily have the semantics of the exclusion negation, although, to my knowledge, only Seuren has been brave enough to suggest an alternative. Seuren's preferred vehicle for denial is an operator which maps only $\star$ onto t, and maps both t and f onto f. I know of no other negation discussed in the literature for which double negation produces a constant f-function. Seuren has marshaled considerable empirical evidence that negation is in fact ambiguous, although the main justification for his particular choice of denial operator is, I think, philosophical.

he does not formalise this part of the theory. Presumably a default must be invoked that the A operator only occurs when incoherence would result otherwise, and then with narrowest possible scope.[13]

So far we have only considered cases where presuppositions of each argument are either definitely projected to become presuppositions of the whole, or definitely not projected. Fittingly, in the land of the *included* middle, there is a third possibility. The presupposition may, in effect, be modified as it is projected. Such modification occurs with all the binary connectives in Kleene's *strong* system [Kl45, Kl59]:

Definition 6 (The Strong Kleene Connectives)

$\phi \wedge \psi$	t	f	$\star$
t	t	f	$\star$
f	f	f	f
$\star$	$\star$	f	$\star$

$\phi \vee \psi$	t	f	$\star$
t	t	t	t
f	t	f	$\star$
$\star$	t	$\star$	$\star$

$\phi \rightarrow \psi$	t	f	$\star$
t	t	f	$\star$
f	t	t	t
$\star$	t	$\star$	$\star$

ϕ	$\neg\phi$
t	f
f	t
$\star$	$\star$

To see that under this definition it is not in general the case that if ϕ presupposes π then $\psi \rightarrow \phi$ presupposes π, we need only observe that if $[\![\psi]\!]_w = f$ then $[\![\psi \rightarrow \phi]\!]_w$ is defined (and $= t$) regardless of the valuation of ϕ. Presuppositions of the consequent are weakened, in the sense that in a subset of worlds, those where the antecedent is false, undefinedness of the consequent is irrelevant to the definedness of the whole. However, in those worlds where the antecedent is not false, the presuppositions of the consequent are significant, so that presupposition failure of the consequent is sufficient to produce presupposition failure of the whole.[14]

To complete the definition of a trivalent PrL semantics can add a binary presupposition connective. A formula ϕ_ψ introduces undefinedness whenever ψ is not true:

Definition 7 (Trivalent Presupposition Operator)

ϕ_ψ	t	f	$\star$
t	t	$\star$	$\star$
f	f	$\star$	$\star$
$\star$	$\star$	$\star$	$\star$

The presuppositional properties of the strong Kleene logic may be determined in full by inspection of the truth tables, and can be summed up as follows:

Fact 8 *Under the strong Kleene interpretation, if $\phi \gg \pi$ then :*

$$\begin{aligned}
\neg\phi &\gg \pi \\
\phi \wedge \psi &\gg \psi \rightarrow \pi \\
\psi \wedge \phi &\gg \psi \rightarrow \pi \\
\phi \rightarrow \psi &\gg (\neg\psi) \rightarrow \pi \\
\psi \rightarrow \phi &\gg \psi \rightarrow \pi \\
\phi \vee \psi &\gg (\neg\psi) \rightarrow \pi \\
\psi \vee \phi &\gg (\neg\psi) \rightarrow \pi
\end{aligned}$$

If models are restricted to those where ψ is bivalent, 8 gives the maximal presuppositions in the sense that the right hand side represents the logically strongest presupposition, all other presuppositions being $\models$-entailed by it.

[13] Observe that in Link-type theory the lexical ambiguity of negation which is common in trivalent theories is replaced by an essentially structural ambiguity, and in this respect is comparable with the Russellian scope-based explanation of projection facts. Horn [Horn85, p.125] provides a similar explication to that above of the relation between theories postulating alternative 3-valued negations and theories involving a Russellian scope ambiguity.

[14] C.f. the discussion of conditional presuppositions in §6.3, below.

2.2 Supervaluations

Van Fraassen's method of *supervaluations* enables a partial treatment of presupposition to remain faithful to classical logic, although in fact the technique is of sufficient generality that it could equally be used to introduce partiality into non-classical logics.[15] The name *supervaluation* reflects the idea that the semantics of a formula reflects not just one valuation, but many valuations combined. Suppose that we have some method, let us call it an *initial partial valuation*, of partially assigning boolean truth values to the formulae of some language. Van Fraassen's idea is to consider all the ways of assigning total valuations to the formula which are compatible both with the initial partial valuation and with principles of classical logic: call these total valuations the *classical extensions* of the initial partial valuation. A new partial valuation, let us call it the *supervaluation*, is then defined as the intersection of the classical extensions, that valuation which maps a formula to *t* iff all the extensions map it to *t*, and maps a formula to *f* iff all the extensions map it to *f*. To justify the approach, it is helpful to think of $\star$ as meaning not "undefined", but "unknown": the values of some formulae are unknown, so we consider all the values that they *might* conceivably have, and use this information to give the supervaluation.

It will now be shown how this technique can be used in the case of PrL, but it should be noted that the application will be in some respects non-standard. Supervaluation semantics is normally given for systems where partiality arises in the model. Here it will be assumed that the model provides a classical interpretation for all proposition letters, and that partiality only arises in the recursive definition of the semantics, specifically with regard to the binary presupposition connective. To simplify, let us restrict the language by requiring that both arguments of any compound formula ϕ_ψ are atomic proposition letters. The notion of an *extension* to a world which will be used is odd in the sense that a world is already total wrt. interpretation of atomic proposition letters. The extension provides a valuation for presuppositional formulae: it is as if we were considering formulae ϕ_ψ to be 'extra' atomic formulae. Since there are many such presuppositional formulae, and two ways of providing a classical value to each one, there are many extensions for each world. The following three definitions give a set of extension functions for a world, a recursive redefinition of the semantics in terms of these extensions, and the resulting supervaluations.

Definition 9 (Extensions of a world) *The set of extensions of w is denoted EX(w), where $EX(w) = \{\langle w, \pi\rangle \mid \pi$ maps every formula of the form ϕ_ψ, for atomic ϕ and ψ, to an element of $\{t, f\}$ under the restriction that if the interpretation of ψ wrt. w is t (i.e. $I(w, \psi) = t$), then π $\pi(\phi_\psi) = i(w, \phi)\ \}$.*

Definition 10 (Total Valuation Functions) *A classical extension $\langle w, \pi\rangle$ provides a total valuation function $TV_{\langle w,\pi\rangle}$ according to the following recursive semantics: atomic formulae are valued using the interpretation function (supplied by the model) with respect to w, formulae of the form ϕ_ψ have value $\pi(\phi_\psi)$, and other compound formulae are interpreted using the classical truth-tables in terms of the $TV_{\langle w,\pi\rangle}$ valuation of their parts.*

Definition 11 (Supervaluations) *The supervaluation wrt. the world w, SUP(w), is a partial valuation defined by $SUP(w) = \bigcap TV_{\langle w,\pi\rangle}$.*[16] *The set of supervaluations S wrt. a model w is $\{s \mid \exists w \in W\ s = SUP(w)\}$.*

To see that supervaluations are partial, consider the formula $A \wedge A_B$ with respect to SUP(w), where A is true and B is false in the world w. Some of the extensions of w will make A_B true, and others will make it false, and likewise some valuations will make $A \wedge A_B$ true and others will make it false. Thus the intersection of the extensions will map $A \wedge A_B$ to the third value, $\star$. On the

[15] Supervaluations are introduced by van Fraassen in [vF69, vF75]. There are a number of good presentations designed to be accessible to linguists, e.g. in Mc.Cawley's [McC81], Martin's [Ma79] and Seuren's [Seu85]. For an application of supervaluations see Thomason's [Th72].

[16] If V is a set of valuation functions, $\bigcap V$ is that function such that: $(\bigcap V)(\phi) = t$ if $forallv \in V\ v(\phi) = t$; $= f$ if $\forall v \in V\ v(\phi) = f$; and $= \star$ otherwise.

other hand, undefinedness does not always project. For example SUP(w) gives $A \vee A_B$ the value t, since the left disjunct is true in w, and thus also true in all extensions, from which it follows that the disjunction is true in all extensions.

The supervaluation semantics is non-truth-functional. That is, the supervaluation of a compound cannot be calculated from the supervaluation of its parts. Consider SUP(w) for the formulae (i) $A_B \vee \neg(A_B)$ and (ii) $A_B \vee (A_B)$, again supposing that A is true and B is false in w. Although SUP(w) makes both A_B and $\neg(A_B)$ undefined, it gives $A_B \vee \neg(A_B)$ the value t. The reason for this is that in all the extensions where A_B is true, $\neg(A_B)$ is false, and *vice versa*. Thus in every extension to w one of the disjuncts of formula (i) is true, so the formula as a whole is true in every extension, and thus in SUP(w) as well. On the other hand, formula (ii) is given the supervaluation $\star$ wrt. w, since there are some extensions where both disjuncts are false, so that the formula as a whole is false, and some extensions where both disjuncts are true, so that the whole formula is true. Since the extensions do not maintain a concensus as to the value of (ii), it cannot be bivalent. Thus both (i) and (ii) are disjunctions where the disjuncts have the same value wrt. SUP(w), but the disjunctions have different values wrt. SUP(w). This establishes the non-truth-functionality of the supervaluation semantics for PrL.

Despite this non-truth-functionality, some general principles of truth-value inheritance are followed, and an imprecise truth-tabular characterisation of the supervaluation semantics is sometimes given: this can be helpful when comparing to other partial and trivalent approaches.

Definition 12 (Truth-table Approximation to Supervaluation Semantics) [17]

$\phi \wedge \psi$	t	f	$\star$
t	t	f	$\star$
f	f	f	f
$\star$	$\star$	f	$(f/\star)$

$\phi \rightarrow \psi$	t	f	$\star$
t	t	f	$\star$
f	t	t	t
$\star$	t	$\star$	$(t/\star)$

$\phi \vee \psi$	t	f	$\star$
t	t	t	t
f	t	f	$\star$
$\star$	t	$\star$	$(t/\star)$

These tables show that for the most part supervaluation semantics resembles the Strong Kleene semantics, providing a value whenever there are classical truth-functional grounds for assigning a value. For instance, a disjunction is true if one of the disjuncts is true, regardless of the value of the other disjunct. But the supervaluation semantics differs from the Strong Kleene when both arguments to a connective are undefined. In this case, the supervaluation semantics takes the principle of maximising bivalence to its limit, sometimes managing to attribute bivalence even though both argument values are undefined.

To what logic does supervaluation semantics lead? It is natural to define $\models$ using preservation of truth wrt. supervaluations, i.e. $\phi \models \psi$ iff for every supervaluation s in S, if $s(\phi) = t$ then $s(\psi) = t$. The resulting logic is distinctly presuppositional. For instance, it is easily verified that both $\phi_\psi \models \psi$ and $\neg(\phi_\psi) \models \psi$. Further, the presuppositional properties are comparable with those of the Strong Kleene system, so that presuppositional implications are commonly weakened. But what marks the supervaluation definition of $\models$ out from all the others considered in this chapter is that all classical argument patterns remain valid. For instance the law of the excluded middle $\models \phi \vee \neg\phi$ holds for any choice of ϕ[18]. This takes us to one commonly made observation which never ceases to amaze me: supervaluation semantics can yield a system in which the law of the excluded middle holds, but in which bivalence fails, even for disjunctions.

2.3 Two Dimensions

There are no obvious empirical reasons for using more than three truth values in the treatment of presupposition, and thus Occam's razor commonly makes trivalent semantics the preferred basis for a multivalent treatment of presupposition.[19] However, quite apart from the fact that

[17] The tables for negation and the presuppositional connective are as in definitions 6 and 7, respectively.

[18] I write $\models \psi$ if for all χ, $\chi \models \psi$.

[19] Cooper [Co83] presents an interesting empirical justification for the use of a fourth value, suggesting that whilst the third value is used to represent presupposition failure, a fourth value is required to signal acts of presupposition denial. This idea, which enables Cooper to give some explanation of cancellation effects without postulating an ambiguity of negation (or other operators) has not, to my knowledge, been taken up elsewhere.

four-valued logics are sometimes thought to be technically more elegant than their three-valued cousins, the use of four truth values affords theorists the space to pursue a *divide and conquer* strategy, separating issues of presupposition from those of classical truth and entailment. The idea was developed independently, but in rather different forms, by Herzberger [Her73] and Karttunen and Peters [KP79], Herzberger's formulation having been further developed by Martin [Ma77] and Bergmann [Ber81]. The semantic domain is considered as consisting of two two-valued coordinates (*dimensions*), which I will call *assertion* and *presupposition*.[20] Thus, if the four values are represented using a pair of binary digits, with the first representing the assertion, and the second the presupposition, then, for instance, $\langle 0, 1\rangle$ will mean that the assertion is not satisfied, although the presupposition is.

Treating a four valued semantics as consisting of two boolean coordinates allows for a straightforward introduction of the tools of classical logic to study an essentially non-classical system, and this enabled Karttunen and Peters to provide compositionally derived two-dimensional interpretations for a fragment of English using the classical IL of Montague (c.f. Partee's chapter in this volume). To illustrate the approach, let us suppose that expressions of English are associated with two translation functions, $\mathcal{A}$, and $\mathcal{P}$. $\mathcal{A}$ maps expressions to IL formulae representing the assertion, and $\mathcal{P}$ likewise maps to an IL representation of the presupposition. Given that the assertion and presupposition of an expression are assumed by Karttunen and Peters to have identical IL types, and that for English sentences this type is that of truth values, the two dimensional interpretation of a sentence S relative to an IL model M and assignment g will be $\langle [\![\mathcal{A}(S)]\!]_{M,g}, [\![\mathcal{P}(S)]\!]_{M,g}\rangle$. Now we might associate with conditionals, for instance, the following translation rule pair:

$$\begin{aligned} \mathcal{A}(\textsf{If S1 then S2}) &= \mathcal{A}(\textsf{S1}) \rightarrow \mathcal{A}(\textsf{S2}) \\ \mathcal{P}(\textsf{If S1 then S2}) &= \mathcal{P}(\textsf{S1}) \wedge \mathcal{P}(\textsf{S2}) \end{aligned}$$

This particular rule pair, defines a notion of implication comparable with the Bochvar internal implication. If we associate the value $\langle 1, 1\rangle$ with t, $\langle 0, 1\rangle$ with f, and the remaining two values both with $\star$, then a sentence '$\textsf{If S1 then S2}$' will take the value $\star$ just in case either $\textsf{S1}$ or $\textsf{S2}$ takes this value, and otherwise will take the standard classical value.[21]

The same approach is extendible to other types. Let us suppose that a sentence of the form '$\textsf{The guest Xs}$' involves the assertion of the existence of a guest with property $\textsf{X}$ and presupposition of the uniqueness of the guest, and that a sentence of the form '$\textsf{y curtsied}$' carries the assertion that $\textsf{y}$ performed the appropriate physical movement, and the presupposition that $\textsf{y}$ is female. Then assuming appropriate basic translations, constants *guest, curtsied* and *female*, and meaning postulates guaranteeing that, for instance, the constant *curtsied* stands in the correct relation to other constants relevant to the physical act of curtseying, part of the derivation of the meaning of the sentence '$\textsf{The guest curtsied}$' might run — departing somewhat from Karttunen and Peters' original system — as follows:

[20] What are here called *assertion* and *presupposition* are for Herzberger *correspondence* and *bivalence*, and for Karttunen and Peters *entailment* and *conventional implicature*. The theories differ considerably in philosophical motivation, in that whilst Herzberger's could be reasonably termed a semantic account, Karttunen and Peters' is not presented as such. However, the fact that Karttunen and Peters give a pragmatic explication of their second dimension of evaluation is irrelevant to most of the technicalities.

[21] This two dimensional version of Bochvar's internal implication is found in some of the systems proposed in [Her73]. Note that the other Bochvar internal connectives can be defined similarly, such that in each case the assertion is defined entirely in terms of the assertion of the arguments, and the presupposition is defined entirely in terms of the presuppositions of the arguments. This yields what is termed (following Jankowski) a cross-product logic. However, both Herzberger and Karttunen and Peters also define operators for which this property does not hold. For instance, the two dimensional version of Bochvar's assertion operator considered by Herzberger, thought of as a semantics for the English '$\textsf{it is the case that}$' locution, could be defined:

$$\begin{aligned} \mathcal{A}(\text{it is the case that } S) &= \mathcal{A}(S) \wedge \mathcal{P}(S) \\ \mathcal{P}(\text{it is the case that } S) &= T \end{aligned}$$

Here the assertion is defined in terms of both the assertion and presupposition of its argument.

$$
\begin{aligned}
\mathcal{A}(\textsf{the guest}) &= \lambda X[\exists y\, guest(y) \wedge X(y)] \\
\mathcal{P}(\textsf{the guest}) &= \lambda X[\exists y\, guest(y) \wedge \forall z[guest(z) \rightarrow x = z] \wedge X(y)] \\
\mathcal{A}(\textsf{curtsied}) &= curtsied \\
\mathcal{P}(\textsf{curtsied}) &= female \\
\mathcal{A}(\textsf{the guest curtsied}) &= \mathcal{A}(\textsf{the guest}).\mathcal{A}(\textsf{curtsied}) \\
&= \lambda X[\exists y[guest(y) \wedge X(y)]](curtsied) \\
&= \exists y[guest(y) \wedge curtsied(y)] \\
\mathcal{P}(\textsf{the guest curtsied}) &= \mathcal{P}(\textsf{the guest}).\mathcal{P}(\textsf{curtsied}) \\
&= \lambda X[\exists y[guest(y) \wedge \forall z[\textsf{guest}(z) \rightarrow x = z] \wedge X(y)]](female) \\
&= \exists y[guest(y) \wedge \forall z[guest(z) \rightarrow x = z] \wedge female(y)]
\end{aligned}
$$

Thus results in the assertion that a guest curtsied, and the presupposition that there is exactly one guest and that guest is female. The approach seems quite general, but Karttunen and Peters observe, in a by now infamous footnote, that there is a problem associated with their interpretation of existentially quantified sentences. According to their theory, a sentence of the form 'An X Ys' carries the assertion that an individual in the assertional extension of X has the property given by the assertional component of Y. Further, the sentence carries the presuppositions (1) that some individual is in the presuppositional extension of X, and (2) that some individual in the assertional extension of X is in the presuppositional extension of Y. What might be referred to as *the presuppositional binding problem* is that there is no link between the variables bound in the assertion and in the presupposition. In particular, there is no guarantee that any entity satisfies both the assertional and the presuppositional requirements.

For instance, the sentence 'Somebody curtsied' will be given the assertion $\exists y\, person(y) \wedge curtsied(y)$, i.e. that somebody performed the physical act of curtseying, and the presupposition $\exists y\, person(y) \wedge female(y)$, i.e. that somebody is female. Crucially, this fails to enforce the common-sensical constraint that the person who curtsied is female. One possible fix would amount to making all presuppositions also assertions, which is standard in some of the accounts to be considered in the next section. In fact, as will be discussed there, there is a separate reason to make presuppositions also part of the asserted content, for without this one cannot easily explain why although presuppositions are commonly defeasible, presuppositions of simple positive sentences are not. If the presupposition is also part of the assertion, then the reason for this indefeasibility has nothing to do with the presuppositional dimension itself, but derives from the fact that one cannot ordinarily deny one's own assertions, or make assertions which one knows to be false.

2.4 Pragmatic Extensions

Little if any recent work has advocated a pure multivalent/partial account of presupposition. Rather, even where multivalence/partiality is taken as the core of a treatment of presupposition, it is usually assumed that some pragmatic component will be required in addition:

- Karttunen and Peters [KP79] assume that conversational implicatures will strengthen some of the weak presuppositions generated.
- Link [Li86] assumes a mechanism whereby a presuppositional expression can sometimes be *co-asserted*. Whether an expression is indeed co-asserted must be controlled by pragmatic factors (c.f. discussion of the floating-A theory, above).
- Seuren [Seu85] embeds a trivalent system which he terms "PPC(3)" (consisting of a mixture of Kleene Weak and Strong connectives plus an extra negation and implication) within a general theory of discourse interpretation. Further, he supposes that a mechanism of *backward suppletion* (similar to that which is below called *accommodation*) will repair the discourse context in cases of presupposition failure.

- Burton-Roberts [Bu89a] discusses a *meta-linguistic* use of negation which he argues enables treatment of cancellation cases without postulation of a lexical ambiguity of negation. He also provides essentially pragmatic argumentation to establish whether the falsity of a sentence's presupposition leads to the undefinedness of the sentence.

- Kracht [Krac94] argues that processing considerations can influence the way in which a connective is interpreted, and in this way reasons to each connective having multiple (trivalent) realizations.

3 Context Dependence and Part-Time Presupposition

The theories to be discussed in this section have two things in common. Firstly, they are, in a sense, the only true projection theories: the set of presuppositions associated with the utterance of a complex sentence is a subset of the set of elementary presuppositions of that sentence.[22] We can thus say that these theories define (relative to a context) a projection function which determines for each elementary presupposition whether it is projected or not. Secondly, this projection function is context sensitive. Whereas for the theories discussed in the previous section presupposition was understood as a binary relation between sentences, the theories to be discussed now involve definitions of presupposition as a three place relation between a pair of a sentence and a context of evaluation.[23] The context is understood to be created partly linguistically, as a result of previous utterances, and thus the models allow for dynamic effects: the context in which one sentence is evaluated will generally be different from the context in which the following are understood.[24]

The accounts discussed in this section involve *part-time* presupposition (the term is used in Karttunen's [Kar74]), theories where unwanted presuppositions appear to vanish. One can identify two means of producing this effect, which may be termed *cancellation* and *filtering*. These are commonly regarded as opposing approaches to the treatment of presupposition, but the two are closely related variations on a single theme: (1) The grammar and lexicon together encode a way of calculating for each simple sentence a set of *potential presuppositions*. (2) The set of presuppositions of a complex sentence is a subset of the union of the potential presupposition sets of the simple subsentences. Call this subset the *projection set*. (3) The calculation of the projection set is sensitive to linguistic context (conceived of as a set of sentences), and relies on one or both of the following two strategies. The first such strategy can be termed *Local Filtering*. Here, for each subsentence S consisting of an operator embedding further subsentences as arguments, S not only carries its own potential presuppositions, but also inherits a subset of the potential presuppositions of the arguments. In the second strategy, here called *Global Cancellation*, pragmatic principles determine a function from tuples consisting of the context, the set of potential presuppositions, the assertive content of the sentence, and a set of Gricean implicatures of the sentence, to that subset of the potential presuppositions which is projected.

3.1 Plugs, Holes and Filters

Karttunen [Kar73, p.178] introduced the following taxonomy:

[22] Even the Bochvar Internal connectives do not form a projection theory in this strong sense, since logical consequences of presuppositions are themselves presupposed, although they may not be amongst the elementary presuppositions.

[23] Alternatively, if an utterance is defined as a pair of a sentence (or set of sentences) and a linguistic context, then presupposition becomes a two place relation between an utterance and a sentence.

[24] The first of the accounts discussed in this section, Karttunen's model is context dependent, but Karttunen is not explicit about how the context arises. His theory requires that "the presuppositions of a compound that involves logical connectives are, in general, definable only in relation to a given set of other sentences."[Kar73, p.183] This dependence on a contextually given set of sentences distinguishes the theory sharply from any purely partial or multivalent approach to presupposition. Gazdar, whose theory is discussed in §3.2, below, was the first to make explicit the way in which such a set of sentences can be built up dynamically in the process of discourse understanding.

Plugs: predicates which block off all the presupposition of the complement sentence [examples include 'say', 'mention', 'tell, ask'];

Holes: predicates which let all the presuppositions of the complement sentence become presuppositions of the matrix sentence [examples include 'know', 'regret', 'understand', 'be possible', 'not'];

Filters: predicates which, under certain conditions, cancel some of the presuppositions of the arguments [examples include if-then, 'either-or', 'and'].[25]

Karttunen's 1973 paper provides two related models of projection: the second model can be seen formally as a generalization of the first. Definition 13, below, gives a function $\mathcal{P}$ which maps every formula of a language onto a set of formulae which are its presuppositions relative to a context c. This context, what Karttunen calls "a set of assumed facts" should here be a set of formulae, and the first version of Karttunen's model is obtained simply by assuming the context to be empty. The language over which 13 is given is PrL with the addition of two sets of sentential operators **H** and **P**, corresponding to hole predicates and plug predicates respectively.

Definition 13 (Karttunen '73 Presuppositions wrt. a Context c)

(1) $\mathcal{P}_c(p) = \emptyset$ *(for atomic p)*

(2) $\mathcal{P}_c(\phi_\psi) = \{\psi\} \cup \mathcal{P}_c(\phi) \cup \mathcal{P}_c(\psi)$

(3) $\mathcal{P}_c(O\phi) = \emptyset$ *(for $O \in$**P**)*

(4) $\mathcal{P}_c(O\phi) = \mathcal{P}_c(\phi)$ *(for $O \in$**H**)*

(5) $\mathcal{P}_c(\neg\phi) = \mathcal{P}_c(\phi)$

(6) $\mathcal{P}_c(\phi \wedge \psi) = \mathcal{P}_c(\phi \rightarrow \psi) = \mathcal{P}_c(\phi) \cup \{\chi \in \mathcal{P}_c(\psi) \mid c, \phi \not\models \chi\}$

(7) $\mathcal{P}_c(\phi \vee \psi) = \mathcal{P}_c(\phi) \cup \{\chi \in \mathcal{P}_c(\psi) \mid c, \neg\phi \not\models \chi\}$

(8) $\phi \gg_c \psi$ *iff* $\psi \in \mathcal{P}_c(\phi)$

(9) $\phi \gg \psi$ *iff* $\phi \gg_\emptyset \psi$

The first five clauses of this definition are straightforward: atomic formulae, by assumption, have no presuppositions; a formula ϕ_ψ presupposes ψ and anything that ϕ or ψ presupposes; a plug embedding a formula carries no presuppositions, whilst a hole (of which internal negation is an example) carries just the presuppositions of its sentential argument. The binary connectives, which act as filters, are more interesting. Firstly, conjunction and implication. These carry all the presuppositions of the first argument, but only those presuppositions of the second argument which are not entailed by a combination of the context and the first argument. Consider the following:

(10) If David wrote the article and the knowledge that ([i] he wrote it/[ii] no decent logician was involved) disturbs the editors, they'll read the manuscript very carefully.

The presupposition that David wrote the article triggered in the right hand conjunct of the antecedent of 10(i) is canceled. Even ignoring the context (i.e. setting it to the empty set so as to get the first version of Karttunen's 1973 model), this result is predicted. The LF of 10(i) has the general form $(\phi \wedge \psi_\phi) \rightarrow \chi$. Since the left conjunct of the antecedent entails the presupposition of the right conjunct, the presupposition is filtered.

It is easy to find formulae for which, in the absence of a special context, filtering does not occur. For instance on definition 13 we have (for independent atomic formulae ϕ, ψ, χ, π) that $(\phi \wedge \psi_\pi) \rightarrow \chi \gg \pi$. Thus, in the absence of a special context, 10(ii) is predicted to presuppose that no decent logician was involved (in writing the article). But if a context c contains (or entails) $\phi \rightarrow \pi$, then the presupposition is filtered: $(\phi \wedge \psi_\pi) \rightarrow \pi \gg_c \pi$.

[25] In the later version of Karttunen's theory discussed in §4, filters not only cancel presuppositions, but modify them.

There remains unclarity in Karttunen's filtering theory. What is the status of the "set of assumed facts"? Should this set contain only propositions which are commonly known to all interlocutors, or can it contain propositions which only the hearer, or perhaps only the speaker, take to be common? And what is the status of a presupposition: is it also some sort of assumed fact? What makes it hard to say what presuppositions really are in this account, as well as providing some empirical problems, is that a formula may have contrary presuppositions. For instance the following sentence (of a type originally discussed by Hausser [Hau76]) contains two instances of factive constructions, 'knows' and 'is upset', but the presuppositions conflict with each other, and are not projected:

(11) Either Fred knows he's won or he's upset that he hasn't.

If we analyse 11 as having the form $\phi_\psi \vee \chi_{\neg\psi}$, the set of presuppositions predicted by the above definition is $\{\psi, \neg\psi\}$.

3.2 Global Cancellation

The model presented by Gazdar in [Gaz79a], like Karttunen's revised filtering model, is context sensitive, provides an account of the presuppositions of utterances rather than sentences, and predicts the presuppositions of an utterance to be a subset of the potential presuppositions of the component sentences. Unlike Karttunen's model, the presuppositions are not calculated by bottom-up filtering but by a global cancellation mechanism. All the potential presuppositions of component sentences are collected together into one set, and from that set are removed any members which conflict with (1) propositions in the previous context, (2) the entailments of the utterance, (3) various implicatures associated with the utterance, or (4) each other. Those potential presuppositions surviving this tough selection process go on to become full presuppositions of the utterance.

The basic idea that something cannot be presupposed if that would conflict with implicatures of the utterance is already found in Stalnaker's work [St74, pp.207–210]. Further, Soames proposed independently of Gazdar that defeat by implicature should be the central notion of a theory of presupposition projection: "A speaker who utters a truth-functional compound, question or epistemic modal indicates that he is presupposing all of the presuppositions of its constituents unless he conversationally implicates (or explicitly states) otherwise."[So79, p.653]. Kempson [Kem75], Wilson [Wi75] and Atlas and Levinson [At76, At77, AL81] had all recognised that conversational factors determine whether or not a presupposition is projected, although their general strategy was of trying to find implicature-based explanations of all cases where presuppositions do project, rather than assuming by default that they project and only seeking implicature-based explanations of cases where presuppositions are canceled.

Gazdar's theory of presupposition, however, provides the first formalisation of this type of account. It is set within a dynamic model of meaning, in which discourse contexts — sets of propositions — are progressively updated with the information in succeeding utterances. Note that the dynamism is found only at the level of texts, and does not extend downwards to the interpretation of the constituents of sentences. In this respect Gazdar's model contrasts with the accounts of presupposition proposed by Karttunen [Kar74] and Heim [Hei83a], as well as with the accounts of anaphora proposed by Kamp [Kam81], Heim [Hei82, Hei83b] and Groenendijk and Stokhof [GS91a], all of which employ dynamic interpretation at the subsentence level.

Central to Gazdar's model is his notion of *satisfiable incrementation*. The satisfiable incrementation of a context X with a set Y of propositions is just the original context plus all those propositions in Y which cannot introduce inconsistency, where a proposition y *cannot introduce inconsistency* just in case all consistent subsets of $X \cup Y$ are still consistent after addition of y. The following definition (close to Gazdar's) results:

Definition 14 (Consistency, Satisfiable Incrementation)

$$\begin{array}{rcl} cons(X) & \textit{iff} & X \not\models \bot \\ X \cup\!! Y & = & X \cup \{y \in Y \mid \forall Z \subseteq (X \cup Y)\ \ (\ cons(Z) \rightarrow cons(Z \cup \{y\})\ )\} \end{array}$$

For example, if $X = \{p, q\}$ and $Y = \{\neg p, r, s, \neg s\}$, with all atomic formulae assumed logically independent, then $X \cup\!! Y = \{p, q, r\}$. The proposition $\neg p$ cannot be added because it is inconsistent with X, s cannot be added because there are consistent subsets of $X \cup Y$ (e.g. $\{p, q, \neg s\}$) which become inconsistent when s is added to them, and similarly for $\neg s$.

Gazdar is concerned with reasoning about the hearer's knowledge of the speaker. For that reason a Gazdarian context is just a set of epistemic formulae, formulae of Hintikka's logic of knowledge and belief [Hi62]. The symbol $\models$ will now represent entailment in this logic, and K can be thought of as 'the speaker knows that'. The need for an epistemic logic arises from the treatment of implicatures, some of which are inherently epistemic. The discussion below, unlike Gazdar's original theory, will be restricted to one class of epistemic implicatures, so-called *clausal* implicatures. For instance, a sentence 'if Mary's happy then she is singing' carries a clausal implicature that the speaker does not know whether Mary is in fact happy. More generally, when an utterance does not decide the truth of some embedded sentence there is an implicature that the speaker does not know whether that embedded sentence is true.

Definition 15, below, begins with the potential presuppositions $\mathrm{PP}(\phi)$ of a formula ϕ and the potential implicatures PI: both of these definitions utilise a function 'sub' which is assumed to map a formula onto the set of all its subformula. The potential presuppositions are just those subformulae occurring as subscripts (i.e. as second argument to the presuppositional connective), and potential implicatures are triggered by any subformula for which the formula as a whole neither entails the subformula nor its negation. Using the notation ϕ' to mean a formula of PrL with all the instances of formulae ϕ_ψ replaced by $\phi \wedge \psi$, what we may call *the assertion of* ϕ, a function $\star\phi$ is defined. This maps a context C onto a new context which is just C with the proposition that the speaker knows ϕ' added, and then all the compatible potential implicatures added. The full update of C with a formula ϕ is given by $C + \phi$, which is just $C \star \phi$ with all the compatible presuppositions added. Finally, we arrive at definitions of presupposition: $\phi \gg_C \psi$ holds just in case ψ is added to the context in the presuppositional stage of the update of C with ϕ, and $\phi \gg \psi$, if that is so for an empty context.[26] Additionally we define a presuppositionally sensitive notion of implication, $\Vdash$, is also defined:

Definition 15 (Gazdarian Presuppositions)

$$\begin{array}{rcl} PP(\phi) & = & \{K\psi \mid \textit{for some } \chi, \chi_\psi \in sub(\phi)\} \\ PI(\phi) & = & \{\neg K\psi \wedge \neg K\neg\psi \mid \psi \in sub(\phi) \wedge \phi \not\models \psi \wedge \phi \not\models \neg\psi\} \\ C \star \phi & = & C \cup \{K\phi'\} \cup\!! PI(\phi) \\ C + \phi & = & C \star \phi \cup\!! PP(\phi) \\ \phi \gg_C \psi & \textit{iff} & C + \phi \models \psi \textit{ and } C \star \phi \not\models \psi \\ \phi \gg \psi & \textit{iff} & \phi \gg_\emptyset \psi \\ \phi \Vdash \psi & \textit{iff} & \emptyset + \phi \models \psi \end{array}$$

The reader should verify that under these definitions presuppositions project in simple cases of embedding. Further, cancellation is correctly predicted in a wide range of cases, for instance the following:

(12) The King of France is not bald: there is no King of France.

[26] The definition of presupposition is at variance with that given by Gazdar [Gaz79a, p.133], who defines the presuppositions as those potential presuppositions which are in the final context. But then note that 'Mary won and knows it' would presuppose that Mary won, which is unintuitive. On the other hand, the definition used here is also open to criticism: potential presuppositions in simple positive contexts *never* become presuppositions because they are also entailed.

(13) If the King of France is bald, then I'm a Dutchman: there is no King of France.

(14) I don't know that Louis is bald.

(15) If David wrote the article then the knowledge that he wrote it will confound the editors.

Let ψ be the proposition that there is a French King, and ϕ be the proposition that this individual is bald. Then the first example, 12, becomes $\neg(\phi_\psi) \wedge \neg\psi$. Cancellation is correctly predicted: $\neg(\phi_\psi) \wedge \neg\psi \not\models \psi$. Note that in the absence of further information presuppositions project from negative sentences, so that the first clause alone does imply the existence of a French King: $\neg(\phi_\psi) \models \psi$.

In 13 (as uttered by, say, an Englishman) the presupposition of the definite in the first sentence, that there is a French King, is once again canceled.[27] Clearly more empirical work is needed! On the assumption that the consequent of the conditional is intended as obviously false, and may be translated as if it were simply a contradictory proposition represented by $\perp$, we derive a translation $(\phi_\psi \rightarrow \perp) \wedge \neg\psi$. The Gazdarian account again correctly predicts cancellation: $(\phi_\psi \rightarrow \perp) \wedge \neg\psi; \not\models \psi$. Under the translations given here it is scarcely surprising that 12 and 12 manifest similar projection properties, but note that under some accounts this could be seen as problematic. I am thinking here of theories (like the partial and multivalent theories considered earlier) that explain the occasional failure of presuppositions to project from under negations by postulating an ambiguity of negation, so that the ordinary presupposition-projecting translation of the first clause of 12 alone would in fact use a different negation to that involved in the cancellation reading of the whole example. This position on negation is consistent, but as the beginnings of a general account of the phenomenon of cancellation it is at least tested by examples like 13. For to explain cancellation in 13, the supporter of an ambiguity hypothesis would presumably have to postulate ambiguity of the English conditional. One then wonders where this multiplication of ambiguities will end: could all embedding constructions end up ambiguous between projecting and canceling interpretations? This would be an unattractive result.

Example 14 is a historically interesting type of cancellation sentence which led some theorists, starting with Karttunen [Kar71a], to postulate that there is a class of attitude verbs, the so-called *semi-factives*, which in some cases fail to carry a presupposition. Gazdar [Gaz79a, pp.153–154] was able to show that his theory could be used to formalise an alternative explanation arising with Stalnaker [St74]. Take K to be a modal operator translating 'I know', and translate 'I know that Louis is bald' as $K(\phi)_\phi$, where ϕ is the proposition that Louis is bald. Updating with the formula's assertion results in a context containing $\neg(\phi \wedge K(\phi))$, which in Hintikka's logic entails $\neg K(\phi)$. This is sufficient to prevent the potential presupposition $K(\phi)$ from being projected. It is crucial to the argumentation that the formula explicitly concerns the speaker's beliefs, and it is correctly predicted that whilst cancellation takes place in 14, it does not in the structurally similar 'Marie doesn't know that Louis is bald'. Likewise, no cancellation is predicted if 'know' is substituted for a factive verb that does not assert something about the speaker's knowledge: 'I don't regret that Louis is bald' does imply that the speaker takes Louis to be bald. So the cancellation in 14 does not take place because of any special non-presuppositional meaning of 'know', as Karttunen would suggest, but because the ordinary lexical semantics of 'know' means that it can be used to address issues relevant to projection.

In example 15, translated as $\phi \rightarrow \psi_\phi$, a potential implicature is generated by the occurrence of ϕ in the antecedent of the conditional, which results in $\neg K\phi$ being added to the context. This is sufficient to block projection of the potential presupposition $K\phi$. A similar cancellation effect would be derived for the earlier example 10(i), but, as will be seen later, this type of clausal-implicature dependent cancellation does not always produce the right results.

[27] Kay [Kay92], contra my own intuitions, sheds doubt on whether an example like 13 has a cancellation reading. The example would still be of interest, but if Kay's data is right, 13 is a counterexample to Gazdar's theory (and presumably Kay's own development of Gazdar's theory) rather than providing support.

3.3 The Pre- in Presupposition

In what sense is Gazdar's theory an account of 'presupposition'? I do not mean to suggest that it does not provide an account of presuppositional data. I merely mean that the account does not bear any relation to the fairly intuitive notion of presuppositions as previous assumptions. Indeed, since presuppositions are the last things to be added in Gazdar's definition of update, perhaps it would be more natural to call them *post-suppositions*. To me, at least, the major achievement of the theory first presented in van der Sandt's thesis [vdS82], which only appeared in English somewhat later in [vdS88], is that it does succeed in reconciling ideas from Gazdar's cancellation account with what I take to be the intuitive notion of presupposition. I will term van der Sandt's 1982/88 account his *cancellation* theory, to distinguish it from his later DRT-based theory.

One crucial but disarmingly simple insight could be said to drive van der Sandt's cancellation theory. Suppose a sentence S can be coherently uttered in a context σ, and that one of the constituents of S carries a potential presupposition expressible using the sentence P. If in σ the text made up of P followed by S is coherent, then utterances of S in σ will carry the presupposition P, i.e. P is projected, and otherwise P is canceled (see [vdS88, pp.185–189]). For example, the sentence S= 'If Mary is married then her husband is away.' does not presuppose that Mary has a husband, since the the discourse consisting of 'Mary has a husband.' followed by S is strange.

Coherence of a discourse, what van der Sandt expresses as "acceptability in a context", here comes down to the requirement that every clause is both consistent and informative. And it is in this definition that we see a synthesis of ideas of context change originating with Stalnaker and Karttunen with an otherwise quite Gazdarian account. Acceptability of a sentence S in a context σ is the requirement that for each clause S' appearing in S (other than within a presuppositional expression) σ neither entails S' nor entails the contrary of S'. If this requirement is not met, then S will not be a maximally *efficient* (i.e. compact) way of communicating whatever information it conveys in that context. I simplify by taking a context to be a set of sentences, although van der Sandt allows for contexts to contain certain additional information.

Definition 16 (Presuppositions in van der Sandt's Cancellation Account)
Given that all the potential presuppositions (or elementary presuppositions *in van der Sandt's terminology) of* S *are collected in the set* π*, the presuppositions of* S *in context* σ *are those propositions* ϕ *such that:*

1. $\phi \in \pi$
2. *For any* $\psi \in \pi$, $\sigma \cup \{\phi, \psi\} \not\models \bot$
3. S *is acceptable in the context* $\sigma \cup \{\phi\}$

Although there are problems associated with this definition[28], the intuition is clear, as the treatment of as treatment of 16 should illustrate:

(16) If Mary is sleeping then Fred is annoyed that she is sleeping.

Suppose that the context is empty. For 16, π is just the singleton set {*Mary is sleeping*}, the one potential presupposition being triggered by the factive 'annoyed'. We can test whether the potential presupposition is actually presupposed by adding it to the context and checking that all the subsentences in 16 not appearing in presuppositional expressions are neither entailed nor contradicted in the resulting context. Since the resulting context {*Mary is sleeping*} entails one of the subsentences, i.e. the antecedent of the conditional, we can conclude that the proposition that Mary is sleeping is not being presupposed, for if it were then 16 would be inefficient, and hence unacceptable.

Aside from van der Sandt's proposal, there are by now a number of other theories which utilise Gazdar's approach of making presuppositions true by default. Mercer's cancellation account

[28] See my [Bea95] and Burton-Roberts review article, [Bu89c], for discussion of problems with van der Sandt's definition of presupposition.

[Me87, Me92] takes Gazdar's insight that presuppositions *normally* project, and are only canceled as a result of conflict with context or implicatures, and formalises that by explicitly encoding Gazdar's potential presuppositions as default inference rules within Reiter's Default Logic. Unlike Gazdar, Mercer explicitly formulates his theory in terms of a notion of presupposition sensitive implication, that notion of implication being drawn directly from Default Logic. Indeed, Mercer describes his theory as not being a theory of presupposition projection *per se*, but as a theory of presuppositional inference. Other cancellation accounts include those of Bridge [Br91], Gervas [Ger95], Gunji [Gu81], Horton [Hort87, HH88], Marcu [Ma94], Morreau [Morr95], and Schöter [Schö95, Schö:MS]. These accounts exhibit considerable technical and descriptive variation, but all centre on presuppositions being defeasible inferences.

4 Context Change and Accommodation

We have already seen that the cancellation theory of Gazdar [Gaz79a], although based on a classical static semantics, involves pragmatic mechanisms controlling the evolution of a set of accepted propositions. Whereas in Gazdars account meanings are derived statically, and dynamic effects become important only secondarily, in the accounts now to be discussed meaning itself is conceived of dynamically. We will be concerned with accounts which extend the inter-sentential dynamism of Gazdar's account by employing dynamism intra-sententially, so that the context of evaluation of a given clause is determined not only by previous sentences, but also by the dynamic interpretation of other parts of the same sentence.

The dynamic models of presupposition that will be considered all run along the following lines: (1) A context is comparable to a partial model, with respect to which some propositions are satisfied, some are falsified, and others are neither satisfied nor falsified. For some, these contexts may be understood as mental representations of discourse information. Sentences are interpreted as update operations mapping contexts to contexts. (2) When evaluating a complex syntactic expression in a certain context, the semantics of the functor should determine what input contexts are used locally in the evaluation of the argument expressions. Basic projection facts are explained by assuming that a complex expression is only admissable in a context if the the argument expressions are all admitted in their local input contexts. (3) A mechanism of *accommodation* may modify contexts so as to guarantee admissability of presuppositional expressions.

4.1 From Projection to Satisfaction

Karttunen's 1973 definition of presupposition involved "a set of assumed facts", utterance presuppositions being calculated relative to such a set. However, it is not clear in this theory how the set of assumed facts and the set of (utterance) presuppositions are to be understood, and what, from a philosophical perspective, is meant to be the relation between them. In [Kar74] Karttunen brilliantly resolved these difficulties, essentially by turning the projection problem, as then conceived, on its head. Instead of considering directly how the presuppositions of the parts of a sentence determine the presuppositions of the whole, he suggests we should first consider how the global context of utterance of a complex sentence determines the local linguistic context in which the parts of the sentence are interpreted, and derive from this a way of calculating which global contexts of utterance lead to local satisfaction of the presuppositions. He gives a formal definition of when a context satisfies-the-presuppositions-of — or *admits* — a formula. A simple sentence p will be admitted in a context A (here written $A \rhd p$) if and only if the primitive presuppositions of p are satisfied in A, where the natural notion of contextual satisfaction is just classical entailment. When a complex sentence is evaluated in some context, however, presuppositions belonging to the parts of the sentence need not necessarily be satisfied in that context. For example, if a sentence S of the form "p and q" occurs in a context A, the conditions for S to be admitted in A are that p is admitted in A and q is admitted in a new context produced by adding p to A. Note that essentially the same idea was independently developed by Stalnaker [St73, p.455]. Definition 17, below, shows how the approach can be applied to PrL:

Definition 17 (Admittance)

(17) $A \rhd \phi_\psi \quad \textit{iff} \quad A \models \psi \textit{ and } A \rhd \phi$

(18) $A \rhd p \quad \textit{for any atomic } p$

(19) $A \rhd \neg\phi \quad \textit{iff} \quad A \rhd \phi$

(20) $A \rhd \phi \wedge \psi \quad \textit{iff} \quad A \rhd \phi \textit{ and } A \cup \{\phi\} \rhd \psi$

(21) $A \rhd \phi \rightarrow \psi \quad \textit{iff} \quad A \rhd \phi \textit{ and } A \cup \{\phi\} \rhd \psi$

(22) $A \rhd \phi \vee \psi \quad \textit{iff} \quad A \rhd \phi \textit{ and } A \cup \{\neg\phi\} \rhd \psi$

Presupposition may be formally defined as follows:

Definition 18 *The Presupposition of a formula are those formula which are satisfied in every context that admits it:*

$$\phi \gg \psi \quad \textit{iff} \quad \forall A \; A \rhd \phi \Rightarrow A \models \psi$$

The empirical motivation Karttunen presents for this theory is much the same as for his earlier theory. For instance, consider the formula $(\phi \wedge \psi_\phi) \rightarrow \chi$, which was given as a translation for 10(i). Admittance of the whole formula in a context A depends on admittance of the formula ψ_ϕ in a local context $A \cup \{\phi\}$: but this is guaranteed irrespective of A. Thus the formula as a whole is admitted in all contexts, and there is no non-trivial presupposition.

This is more or less the result that would have obtained in the earlier theory, but note the "more or less" caveat. Whereas Karttunen's 1973 theory predicts no presupposition for this example, the 1974 theory predicts that all tautologies are presupposed by every formula. Furthermore, when the 1974 theory does predict a non-trivial presupposition, all the entailments of that presupposition are also presuppositions themselves, unlike in the 1973 theory. This difference is revealing, for it shows that [Kar74] is not a filtering model: the presuppositions of a sentence are not in general a subset of the elementary presuppositions of its parts. Furthermore, the difference is not just that entailments of presuppositions are predicted to be presupposed. In some cases the 1974 account predicts a non-trivial presupposition when the earlier model would predict no presupposition at all.[29] Here is a summary of the presupposition projection properties arising from definitions 17 and 18:

Fact 19
If ϕ presupposes ψ then:

1. $\neg\phi$, $\phi \wedge \psi$, $\phi \rightarrow \psi$ *and* $\phi \vee \psi$ *all presuppose* ψ
2. $\chi \wedge \phi$, $\chi \rightarrow \phi$ *and* $\chi \vee \phi$ *all presuppose* $\chi \rightarrow \phi$
3. $\chi \vee \phi$ *presupposes* $\neg\chi \rightarrow \phi$

It can be seen that when a presupposition trigger is found on the right-hand side of a connective, a conditional presupposition results, although this conditional will not in general be one of the elementary presuppositions itself. So a concrete case where the 1973 and 1974 theories vary is the formula $\phi \rightarrow \psi_\chi$. With null context, the 1973 model predicts the presupposition χ, whereas the 1974 theory predicts the conditionalised presupposition $\phi \rightarrow \chi$.[30]

[29] A similar point is made by Geurts in [Geu95].

[30] The PrL admittance definition does not cover Karttunen's full treatment of predicates taking propositional complements. He divided these into three classes: verbs of saying (eg.*say*, *announce*), verbs of propositional attitude (eg. *believe, want*), and others. On Karttunen's account, the simplest cases are the first and the third: presuppositions triggered within the complement of a verb of saying do not impose any constraint on the context of utterance, whilst for members of the third class all presuppositions must be satisfied. Thus "John says that the king of France is bald" should be acceptable in any context, and "John knows that the king of France is bald" should only be acceptable in contexts where there is a (unique) king of France. For a sentence with propositional attitude verb as matrix, Karttunen argues that it is the beliefs of the subject of the sentence which are crucial: for a context A to

4.2 Context Change Potential

In Karttunen's 1974 model it is unclear what the relationship is between the definition of admittance for an expression and the semantics of that expression. Judging from the developments in Karttunen and Peter's later work [KP79], one might conclude that admittance conditions and semantics are separate and unrelated parts of a grammar, but some authors see this as a weakness of the theory. Gazdar [Gaz79b, pp. 58–59], who does not distinguish between the Karttunen's 1973 and 1974 accounts, caricatures Karttunen's justification for why presuppositions sometimes disappear as "Because those presuppositions have been filtered out by my filter conditions." Gazdar suggests that an explanatorily adequate model should not only stipulate filtering conditions, but provide independent motivation for why those conditions are as they are. Although it is difficult to give any definitive characterisation of exactly when a theory of presupposition is explanatorily adequate — and Gazdar's rhetoric provides no such characterisation — it is at least clear that it would be desirable to justify a particular choice of filtering or admittance conditions. Heim [Hei83a] attempts to provide such a justification, and at the same time to clarify the relationship between admittance conditions and semantics. In particular, Heim provides a method of stating semantics, based on the approach developed in [Hei82], in such a way that admittance conditions can be read off from the semantic definitions without having to be stipulated separately. Crucially, Heim's semantics involves a significant deviation from the classical Tarskian approach, in that rather than viewing meaning as a static relation holding between language and truth in the world, she takes the meaning of an expression to be a method of updating the information state of communicating agents. I will now present Heim's insights in terms of PrL, the reader being referred to the chapter on Dynamic Semantics in this volume for a more careful discussion of the dynamic semantic approach.[31]

In definition 20 a dynamic semantics is given for PrL. Formulae are interpreted as relations between pairs of information states, the intuition being that if a pair $\langle \sigma, \tau \rangle$ is in the denotation of a formula, then it is possible to update the state σ with the formula to produce the state τ. Information states are fashioned after the conception in Stalnaker's [St79] as sets of possible worlds, the idea being that the set of worlds in an information state represents the set of different ways the world could be whilst maintaining consistency with all the available information. There are several ways we could answer the question of exactly what an information state is supposed to be a state of, it being left open for the moment whether a state represents the information of some particular agent, such as a hearer, or represents the commonly agreed information, or *common ground*, of a group of communicating agents. The clause for atomic propositions in 20 says that to update a state with an atomic proposition, all the worlds incompatible with the proposition must be removed, it being assumed that the model provides an interpretation function mapping each proposition to a corresponding set of worlds. The next clause says that to update with a conjunction it is necessary to update sequentially with the left and then the right conjunct, and the final clause says that to update with the negation of a formula one must find the set of worlds that is compatible with the formula, and remove these from the information state.

Definition 20 (Semantics of an Update Logic) *For all models $\mathcal{M}$ and information states*

admit the sentence, the beliefs of the subject in that context must satisfy all the presuppositions of the propositional complement. Thus "John hopes that the king of France is bald" should be satisfied in contexts where it is satisfied that John believes there to be a king of France. In favour of this analysis is the fact that the sentence "Although France is not a monarchy, John believes that there is a reigning French king: he hopes that the King of France is bald", although contrived, is felicitous. The syntax of PrL could be enriched with formulae $\alpha(\phi)$ for α taken from one of three sets of predicates $\mathcal{S}$, $\mathcal{A}$ and $\mathcal{F}$ (for *Saying, Attitude* and *factive*, respectively). I will ignore members of the *other* class apart from factives. Assuming that *believes* $\in \mathcal{A}$, and further assuming that neither verbs of saying nor verbs of propositional attitude induce any new presuppositions, the following are essentially Karttunen's acceptability conditions: (1) for $\alpha \in \mathcal{S}$, $A \rhd \alpha(\phi)$; (2) for $\alpha \in \mathcal{A}$, $A \rhd \alpha(\phi)$ *iff* $\{\psi \mid A \models \mathit{believes}(x, \phi)\} \rhd \phi$; (3) $\alpha \in \mathcal{F}$, $A \rhd \alpha(\phi)$ *iff* $A \models \phi$

[31] The move to a dynamic semantic style of presentation for Karttunen-Heim type theories was made by van Eijck [Ei93], Zeevat [Ze92] and myself [Bea92]. More recent work along these lines may be found in my [Bea95, Bea94a], Chierchia's [Ch:95], and Krahmer's [Krah93]. The presentation here is closest to that of Krahmer.)

σ, τ, *the relation* $[\![.]\!]^{\mathcal{M}}$ *(sub-script omitted where unambiguous) is given recursively by:*

$$\begin{array}{rll} \sigma[\![p_{\text{atomic}}]\!]\tau & \textit{iff} & \tau = \{w \in \sigma \mid w \in F(p)\} \\ \sigma[\![\phi \wedge \psi]\!]\tau & \textit{iff} & \exists \upsilon \ \sigma[\![\phi]\!]\upsilon[\![\psi]\!]\tau \\ \sigma[\![\neg\phi]\!]\tau & \textit{iff} & \exists \upsilon \ \sigma[\![\phi]\!]\upsilon \ \wedge \ \tau = \sigma \backslash \upsilon \end{array}$$

One may add extend this language with clauses for implication and disjunction using the following suitably chosen classical equivalences:

Definition 21 (Defined Connectives)

$$\begin{array}{rll} \sigma[\![\phi \rightarrow \psi]\!]\tau & \textit{iff} & \sigma[\![\neg(\phi \wedge (\neg\psi))]\!]\tau \\ \sigma[\![\phi \vee \psi]\!]\tau & \textit{iff} & \sigma[\![\neg(\neg\phi \wedge \neg\psi)]\!]\tau \end{array}$$

A state σ is said to satisfy a formula ϕ (written $\sigma\|\!=\!\phi$) if and only if the state is a fixed point of the formula. This means that updating the state with the formula will add no new information. One formula ϕ entails another ψ (written $\phi\|\!=\!\psi$) if any update with the premise formula produces a state for which updating with the second adds no information.[32]

Definition 22 (CCP Satisfaction and Entailment)

$$\begin{array}{rll} \sigma \models \phi & \textit{iff} & \sigma[\![\phi]\!]\sigma \\ \phi \models \psi & \textit{iff} & \forall \sigma, \tau \sigma[\![\phi]\!]\tau \Rightarrow \tau \models \psi \end{array}$$

Over the standard connectives, the entailment relation is extensionally identical to the classical relation. But the full logic including presuppositional constructions is non-classical, e.g. in the sense that classical Gentzen sequents are no longer valid. The following definition captures the intuition that presuppositions place constraints that an input context must satisfy in order for there to be an update:

Definition 23 (CCP Semantics of the Presupposition Connective)

$$\sigma[\![\phi_\psi]\!]\tau \quad \textit{iff} \quad \sigma \models \psi \textit{ and } \sigma[\![\phi]\!]\tau$$

For the full language, conjunction is not commutative: e.g. the denotations of $\phi \wedge \phi_\psi$ and $\phi_\psi \wedge \phi$ are different, and the first may be entailed by a formula which does not entail the second. The following justifies the claim that Karttunen's admittance conditions, and thus his notion of presupposition can be read off from the semantics:

Fact 24

$$\phi \rhd \psi \quad \textit{iff} \quad \forall \sigma, (\exists \tau \sigma[\![\phi]\!]\tau) \textit{ iff } \sigma \models \phi$$

Suppose we were to make the philosophically controversial claim that a statement "X knows S" presupposes S and asserts that X believes S. Then 'Elspeth knows that Fred is happy' might be represented as *bel(e, happy(f))*$_{happy(f)}$. Write this formula, where *happy(f)* and *bel(e,happy(f)* are atomic propositions, as ϕ. Let the model contain only four worlds, 1–4, such that Fred is happy in the first two (i.e. $\mathcal{I} = \{1, 2\}$), and Elspeth believes that Fred is happy in the first and the third. Consider update of the state $\{1, 2\}$ with ϕ. It is necessary firstly to check that *happy(f)* is satisfied, which it is: $\{1, 2\} \models$ *happy(f)*. The state must then be updated with *bel(e, happy(f))*. Since this proposition holds in world 1 but not in world 2, the final output is the state $\{1\}$. In contrast, the formula ϕ does not define an update from input state $\{1, 3, 4\}$ in this model,

[32] See the chapter on Dynamic Semantics in this volume for discussion of alternative notions of entailment.

since $\{1,3,4\} \not\models$ *happy(f)* and if a presupposition is not satisfied, updating is blocked. In fact in this model the update relation corresponding to the denotation of ϕ defines only the updates $\{1,2\} \Longrightarrow \{1\}, \{1\} \Longrightarrow \{1\}, \{2\} \Longrightarrow \{\}$. There are no updates from states containing worlds 3 or 4, since the presupposition is not satisfied in any of these states. More generally, if 24 and 18 are taken as the definition of presupposition for this system, then for arbitrary models it will be the case that $\textit{bel(e, happy(f))}_{\textit{happy(f)}} \models \textit{happy(f)}$.

Note the distinction between presupposition failure and update with contradictory information: whereas there is no state that can be obtained by updating $\{1,3,4\}$ with ϕ, there is a state which can be obtained by updating $\{2\}$ with ϕ. However, this output state is the empty set, there being no worlds in the model compatible with all the information the agent has. It is also worth noting that for this system the definition of presupposition via admittance is equivalent with one of the standard semantic notions of presupposition introduced above:

Fact 25 *ϕ presupposes ψ iff $\phi \models \psi$ and $\neg\phi \models \psi$*

The reason for this lies in the clause for the interpretation of negation, from which it may be seen that the negation of a formula defines an update just in case its positive counterpart does. It is thus obvious that if 'Elspeth doesn't know that Fred is happy' is represented as $\neg\phi$, then 'Elspeth doesn't know that Fred is happy' has the same presuppositions as 'Elspeth knows that Fred is happy'. The reader may care to verify that in the above model, the denotation of $\neg\phi$ defines only the updates $\{1,2\} \Longrightarrow \{2\}, \{1\} \Longrightarrow \{\}\{2\} \Longrightarrow \{2\}$, mapping states in which it is established that Fred is happy, but not established whether Elspeth believes this, to states where it is both established that Fred is happy and that Elspeth does not believe this.

4.3 Quantifying-in to Presuppositions

It is not obvious how to extend the cancellation accounts considered in the previous section to enable them to deal with open presuppositions, that is, presuppositions containing a free variable. Heim showed how this might be achieved in the Context Change model. We will consider her approach presented in terms of an extension to the above propositional dynamic logic, and then look at a well known problem with that approach, and, briefly, some possible solutions.

One could imagine introducing variables into the above system in a relatively conservative fashion, maintaining classical notions of scope and binding.[33] The approach Heim took, developed from that in her thesis, was more radical, and allows for binding of variables which fall outside of the conventional scope of their introducing quantifier. This non-standard treatment of variables was originally motivated in terms of pronomina in donkey and intersentential anaphora, but given the tight relationship between presupposition and anaphora, to which we shall turn later, it is also of relevance to presupposition, most obviously for definite descriptions.

Models will now be triples $\langle W, \mathcal{D}, \mathcal{I}\rangle$, where W is a set of worlds, $\mathcal{D}$ is a domain of individuals (here assumed constant across worlds) and $\mathcal{I}$ maps n-ary predicates onto sets of (n+1)-ary tuples, where the first element of the tuple is understood as a world index. Heim utilises *sequences*, such that given a set of variables $\mathcal{V}$, a sequence is just a partial assignment function mapping a subset of $\mathcal{V}$ onto elements of $\mathcal{D}$. A Heimian information state is a set of sequence-world pairs where each sequence has the same domain of variables. Each pair encodes one possibility for how the world is and which objects in that world are under discussion.

Before coming to the technicalities, let us consider a simple example: update with 'a woman curtsied', which will be represented as $\exists x\ (\textit{woman}(x) \wedge \textit{curtsied}(x)_{\textit{female}(x)})$. Suppose that there

[33] Assuming the model provided appropriate interpretation functions $\mathcal{I}$ and domains $\mathcal{D}$, we might add the following clauses:

$$\begin{aligned} \sigma[\![P(x_1,\ldots,x_n)]\!]_{\mathrm{f}}\tau \quad & \textit{iff} \quad \tau = \{w \in \sigma \mid \langle w, f(x_1),\ldots,f(x_n)\rangle \in \mathcal{I}(P)\} \\ \sigma[\![\exists x\phi]\!]_{\mathrm{f}}\tau \quad & \textit{iff} \quad \exists d \in \mathcal{D}\ \ \sigma[\![\phi]\!]_{f[x\ \mapsto\ d]}\tau \end{aligned}$$

Here interpretation is with respect to an assignment function, and $f[x \mapsto d]$ denotes the interpretation function differing from f maximally through mapping x onto the object d in the domain.

are only two worlds in the model, w_1 and w_2, and that the domain contains only two individuals *elspeth* and *fred*, such that in both worlds *elspeth* is a *woman* and *female* but *fred* is not. Thus, for example, $\mathcal{I}(woman) = \{\langle w_1, elspeth\rangle, \langle w_2, elspeth\rangle\}$. Suppose that *elspeth curtsied* in w_1 but not w_2. A minimal state of information with respect to this model will be one where both worlds are still possible and where no individuals have been introduced. If we represent a sequence as a list of mappings of the form "var↦object", such that the empty sequence is just an empty list [], then such a minimal state will be $\{\langle [], w_1\rangle, \langle [], w_2\rangle\}$. Update of this state begins with extension with valuations for x, which produces a state $\{\langle [x \mapsto elspeth], w_1\rangle, \langle [x \mapsto elspeth], w_2\rangle, \langle [x \mapsto fred], w_1\rangle, \langle [x \mapsto fred], w_2\rangle\}$, a state in which although the value of x is under discussion, there is no information about what this value is. Updating this state with $woman(x)$ removes sequence-world pairs which do not map x onto an object in the extension of *woman*, to produce $\{\langle [x \mapsto elspeth], w_1\rangle, \langle [x \mapsto elspeth], w_2\rangle\}$, a state which still contains the same information about what the world is like as the initial state, but which additionally determines that the variable x is mapped to *elspeth*. Given that x is now established to be *female*, the presuppositional formula $female(x)$ is satisfied. If there had been any sequence-world pairs which did not map x onto a *female*, update would have failed. Finally, updating with $curtsied(x)$ removes one sequence world pair to produce the state $\{\langle [x \mapsto elspeth], w_1\rangle\}$.

Following earlier formulations of Heim's insights into DPL-like systems[34], we arrive at definitions for predications and for existential quantification like those in 26 below. The clause for predication is analogous to that for atomic propositions in 20. Those sequence-world pairs which are incompatible with the predication are removed. The remaining sequence-world pairs are those where the extension of the predicate contains the tuple made up of the world and the objects onto which the sequence maps the argument variable. The interpretation of statements "$\exists x\phi$" involves extending a state with all possible valuations for that variable, and then removing all those sequence-world pairs which are incompatible with ϕ. One sequence-world pair $i = \langle f, v\rangle$ extends another $j = \langle g, w\rangle$ with respect to the variable x (written $i >_x j$) if $v = w$, f and g agree on all variables apart from x, but f additionally provides a valuation for x. An information state can be updated with $\exists x\phi$, by extending each of the sequence-world pairs in the state with x and updating the result with ϕ.

Definition 26 *[Predication and Quantification]*[35]

$$\begin{aligned}
\sigma[\![P(x_1,\ldots,x_n)]\!]\tau \quad & \textit{iff} \quad \tau = \{\langle f, w\rangle \in \sigma \mid \langle w, f(x_1),\ldots,f(x_n)\rangle \in \mathcal{I}(P)\}\\
\sigma[\![\exists x\phi]\!]\tau \quad & \textit{iff} \quad \{i \mid \exists j \in \sigma \wedge i >_x j\}[\![\phi]\!]\tau\\
\sigma[\![\forall x\phi]\!]\tau \quad & \textit{iff} \quad \sigma[\![\neg\exists x\neg\phi]\!]\tau
\end{aligned}$$

As things stand the definitions for satisfaction of a formula in a state and for the interpretation of negation are inadequate, since they fail to account for cases where the formula introduces a new variable.[36] If R is a Context Change Potential (i.e. a binary relation between information states)

[34]See the Dynamics chapter for details of DPL, introduced in [GS91a]. Dekker (see eg. [Dek93]) provides a reformulation using partial assignments, and [Bea92] draws in the presuppositional aspects of Heim's proposal.

[35]As observed in [Dek93], the logic of the resulting system is simplified if requantification over the a variable is forbidden. In the current set up, we might define a function "dom" which mapped a state onto the set of variables given valuations in that state, and then add an extra constraint on the clause for addition of a discourse marker. Similarly, the predication clause in 26 seems inappropriate in case a predication is evaluated in a state that does not provide valuations for all the predicated variables, and an extra clause can be added requiring this. We arrive at the following:

$$\begin{aligned}
\sigma[\![P(x_1,\ldots,x_n)]\!]\tau \quad & \textit{iff} \quad \{x_1,\ldots,x_n\} \subseteq \mathrm{dom}(\sigma) \wedge\\
& \qquad \tau = \{\langle f, w\rangle \in \sigma \mid \langle w, f(x_1),\ldots,f(x_n)\rangle \in \mathcal{I}(P)\}\\
\sigma[\![\exists x\phi]\!]\tau \quad & \textit{iff} \quad x\neg \in \mathrm{dom}(\sigma) \wedge \{i \mid \exists j \in \sigma \wedge i >_x j\}[\![\phi]\!]\tau
\end{aligned}$$

[36]To see the problem, observe that the negation of a formula is defined in terms of set subtraction of the set resulting from update with the formula from the input state. But if the formula introduces a new variable, then the result of updating with it will be a disjoint set from the input, so that a negation could only define an identity update.

then call $\downarrow R$ the closure of R, a CCP like R except for not introducing any new variables.[37] This leads to the modified definitions for negation and satisfaction in 27. The propositional clause for conjunction in 20 still makes sense at the first order level, modulo a reinterpretation of the notion of *state*. The definitions for entailment (22) and for the semantics of implications, disjunctions (21) and the presupposition operator (23) are also preserved, except that they are defined in terms of the new clauses for negation and satisfaction.

Definition 27 (Negation and Satisfaction)

$$\begin{array}{rll} \sigma[\![\neg\phi]\!]\tau & \textit{iff} & \exists\upsilon\ \sigma \downarrow [\![\phi]\!]\upsilon\ \wedge\ \tau = \sigma\backslash\upsilon \\ \sigma \models \phi & \textit{iff} & \sigma \downarrow [\![\phi]\!]\sigma \end{array}$$

There is a problem in Heim's approach regarding the interaction of quantifiers with presuppositions, and in the current presentation this problem manifests itself as the following fact:

Fact 28 *If ϕ presupposes π, then $\exists x\ \psi \wedge \phi$ presupposes $\forall\ x\ \psi \rightarrow \pi$*

Suppose that 4.3a is given the crude translation in 4.3b.

(23) a. A plane just landed

b. $\exists x$ plane$(x)\ \wedge$ on-ground$(x)_{\text{was-airborne}(x)}$

By Fact 28, example 4.3b will be predicted to carry the presupposition $\forall x$ plane$(x) \rightarrow$ was-airborne(x) . So, contrary to intuition, the sentence is predicted to carry the presupposition that *every* plane, and not just the one that landed, was airborne. To understand why the universal presupposition occurs, consider how a state I would be updated with 4.3b. Firstly the variable x is initialized, to produce a state J in which there are sequences mapping x onto every object in the domain. Then the proposition plane(x) is added, removing all those sequence-world pairs where x is not mapped onto a plane to produce a state K. Next we arrive at the presupposition was-airborne(x), and update can only continue if this is satisfied in K. For this to be the case every sequence-world pair in K must map x onto an object that was airborne. But since for any world still in contention, there are sequences in K mapping x onto every plane in that world, the proposition was-airborne(x) will only be satisfied if in every world in K, every object which is a plane in that world is an object which was airborne. Thus we arrive at a universal presupposition.

To some extent this problem is idiosyncratic. There are dynamic systems combining treatments of presupposition and quantification, such as those of van Eijck [Ei93], Krahmer [Krah:MS] and Chierchia [Ch:95], where existential sentences do not lead to universal presuppositions. In some of these systems the notion of an information state is quite different from Heim's, and this is at the heart of the different predictions that arise. However a Heimian semantics like that presented above can be adapted so as to avoid problematic universal presuppositions without any alteration to the notion of an information state. It suffices to make alterations either to the semantics of the quantifiers or to the presupposition connective. As discussed in my [Bea94a], a modification to the quantifiers can arguably be motivated on independent grounds. However modifying the presupposition connective, essentially the move made in [Bea92], is perhaps the simpler. Suppose that the function *worlds* maps a Heimian context onto the set of worlds involved in that context: $\textit{worlds}(\sigma) = \{w \mid \exists f\langle w, f\rangle \in \sigma\}$. Then one possibility would be to redefine the presupposition connective as in 29, such that a formula ϕ_ψ allows update to continue just in case update with ψ would not remove any worlds from the input context. By contrast, the earlier definition above was stricter, requiring not only that update with ψ preserves the worlds in the input, but also that it preserves all the sequences associated with those worlds.

[37] Let us say that one sequence-world pair extends (">") another if some finite sequence of extensions of the first produces the second. Now we can define $\sigma \downarrow R\tau$ *iff* $\exists\upsilon\sigma R\upsilon\ \wedge \tau = \{i \in \sigma \mid \exists j > i\ j \in \upsilon\}$. That is, the closure of an update relation allows update of a state σ to a new state τ, where τ is that subset of sequence-world pairs in σ which have extensions in some update with the unclosed relation.

Definition 29

$$\sigma[\![\phi_\psi]\!]\tau \quad \textit{iff} \quad \exists\upsilon\sigma[\![\psi]\!]\upsilon \textit{ and } \textit{worlds}(\sigma) = \textit{worlds}(\upsilon) \textit{ and } \upsilon[\![\phi]\!]\tau$$

Under this definition 28 no longer holds, and existential sentences yield existential presuppositions. This shows that the problems with Heim's account of presupposed open propositions are not as intractable as has been suggested (c.f. [So89]) in the literature.[38]

4.4 Accommodation

> "...ordinary conversation does not always proceed in the ideal orderly fashion described earlier. People do make leaps and short cuts by using sentences whose presuppositions are not satisfied in the conversational context.... But ...I think we can maintain that a sentence is always taken to be an increment to a context that satisfies its presuppositions. If the current conversational context does not suffice, the listener is entitled and expected to extend it as required. He must determine for himself what context he is supposed to be in on the basis of what is said and, if he is willing to go along with it, make the same tacit extension that his interlocutor appears to have made."[Kar74, p. 191]

The process Karttunen here describes, whereby a "tacit extension" is made to the discourse context to allow for update with otherwise unfulfilled presuppositions, is what Lewis later called *accommodation* [Le79].[39] Theories which utilise a mechanism of accommodation, are not classical *static* theories of meaning, but rather theories about the dynamics of the interpretation process.

Two questions are central to understanding the characteristics an accommodation-based theory of presupposition might have:

1. Given that the interpretation of a discourse involves not one linguistic context, but a series of contexts corresponding to different parts of the interpretation process and different parts of the discourse's meaning, in which context should accommodation occur?

2. Given some decision as to the context in which accommodation occurs, exactly how should a hearer determine what the new context is supposed to be?

Heim [Hei83a] was the first author to recognise the significance of the first question, noting that quite different effects could result according to which point in the interpretation of a sentence accommodation occurs. In the Heim/Karttunen account one can distinguish two types of context. There is the *global* context which represents the information agents have after complete interpretation of some sequence of sentences of text, but there are also *local* contexts, the contexts against which sub-parts of a sentence are evaluated.

Updating a context σ with a conditional $\phi \rightarrow \psi$ involves local contexts which we may notate $\sigma + \phi$ and $\sigma + \phi + \psi$ which are involved during the calculation of the update. Suppose that ψ contains some presupposition which is unsatisfied in the context $\sigma + \phi$, so that σ does not admit the conditional. In that case accommodation must occur, adjusting one of the contexts involved

[38] Space permitting, it would have been appropriate to have also discussed the interaction with quantification in the context of other accounts of presupposition. Note that all systems which split presupposition and assertion into separate components of meaning, such as Karttunen and Peters' system, Karttunen's 1973 filtering account and Gazdar's cancellation account, face serious problems in this regard, but that some other approaches, such as that based on a trivalent logic, can be naturally extended to provide an account of quantified presuppositions. Discussions of systems that allow for interaction of quantification and presupposition are found e.g. in [Co83, LZ:83, Bea94a, BK:MS, Krah94, Krah:MS, Ei93, vdS92].

[39] Stalnaker [St72, p. 398] expresses similar sentiments to those in the above Karttunen quotation, commenting that presuppositions "need not be true", and that in some cases a "Minor revision might bring our debate in line with new presuppositions." Interestingly, in the same paragraph Stalnaker talks of certain things being "accommodated" in the light of new presuppositions, although what he is describing here is not how we change our assumptions (the Lewisian notion of "accommodation"), but how *after* we have changed our assumptions we may reinterpret earlier observations.

in the calculation so that ψ is admitted in its local context of evaluation. This might take the form of directly updating the local context in which ψ is to be evaluated with some formula α, so that the final result of updating with the context would not be $\sigma\backslash(\sigma + \phi \setminus (\sigma + \phi + \psi))$, but $\sigma\backslash(\sigma + \phi \setminus (\sigma + \phi + \alpha + \psi))$: this would be called *local accommodation*. On the other hand, an agent might backtrack right back to the initial context, add a formula β to the global context, and then start the update again. This is termed *global accommodation*, and the result of updating would be $(\sigma + \beta)\backslash(\sigma + \beta + \phi \setminus (\sigma + \beta + \phi + \psi))$. There is at least one other possibility. The agent might just backtrack as far as the evaluation of the antecedent, and add some extra information, say γ, into the context in which the antecedent is evaluated, producing a result like $\sigma\backslash(\sigma + \gamma + \phi \setminus (\sigma + \gamma + \phi + \psi))$. Since this last option involves accommodation into a context intermediate between the global context and the context in which the problematic presuppositional construction is actually evaluated, it can be termed *intermediate accommodation*. Clearly the Heimian view on accommodation is highly procedural, and the exact options which are available for accommodation will be dependent on the details of how updating actually occurs, such processing details not being fully specified by the CCP alone.

The Heimian answer to question (1), then, is that accommodation might take place at any time during the interpretation process such as to ensure later local satisfaction of presuppositions. Put another way, accommodation might potentially take place in any of the discourse contexts used in the calculation of a sentence's CCP. Unfortunately, Heim has not provided a detailed answer to question (2). The first theory of accommodation which provides a fully explicit answer to both questions is that of van der Sandt [vdS92].

4.5 Accommodation as a Transformation on DRS's

In van der Sandt's theory Heimian contexts are replaced by explicit discourse representations.[40] Consequently, whereas for Heim accommodation must consist in augmenting a set of world-sequence pairs, van der Sandtian accommodation is simply addition of discourse referents and conditions to a DRS. This difference could be minimised if the CCP model were presented in terms of Heimian *filecards* (c.f. [Hei82, Hei83b]), so that accommodation would consist of either creating new filecards, or adding conditions to existing ones. Regarding question (1), van der Sandt's theory shares the flexibility of Heim's. If a presupposition lacks an antecedent in a DRS, van der Sandt allows accommodation to take place in any discourse context that is accessible from the site of the trigger. Thus once again we can talk of *local accommodation*, meaning accommodation in the DRS where the trigger is represented, *global accommodation* meaning addition of material in the global DRS, and *intermediate accommodation* meaning addition of material in any DRS intermediate on the accessibility path between the global DRS and the site of the trigger.

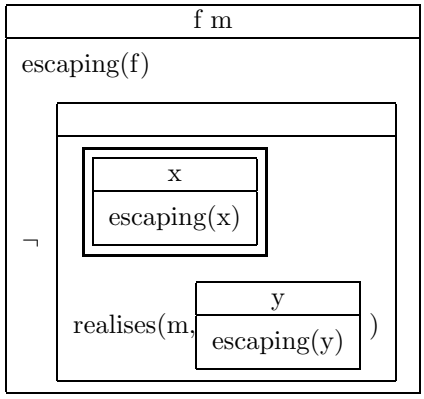
Van der Sandt's answer to question (2), the question of what is accommodated, is as simple as it could be: if a trigger has an antecedentless presupposition, then accommodation essentially consists of transferring the discourse markers and conditions of the presupposition from the trigger site to the accommodation site.

Before van der Sandt's accommodation mechanism can be detailed, the more basic parts of his theory must be discussed, showing how cases not requiring accommodation are treated. Van der Sandt's principle claim is that presupposition triggers are *anaphoric* at the level of discourse representation. The theme of anaphoricity will be taken up again in §6.1, below. For the moment it suffices to realise that the heart of the theory involves a structural relation between the position at which a presupposition trigger is represented in a DRS, and the point at which its *antecedent* is represented. The antecedent must be represented somewhere along the *anaphoric accessibility path* from the representation of the trigger, this condition being exactly the same requirement as is placed on anaphoric pronouns and their antecedents in standard DRT. The treatment of 24 should illustrate.

[40] Van der Sandt is not the only one to have provided an account of presupposition in DRT, but his is the most developed account of projection, and others, such as Kamp and Rossdeutscher's [KRo94, Ros94] (which is more detailed concerning the lexical source of presuppositions) are closely related. For details of DRT, the reader is referred to [Kam81, KRe93] and Chapter ???? of this handbook.

(24) Fred is escaping, but Mary doesn't realise that somebody is escaping.

Initially a DRS like the following, in which the presence of a presupposition is indicated using a double thickness box, is constructed:



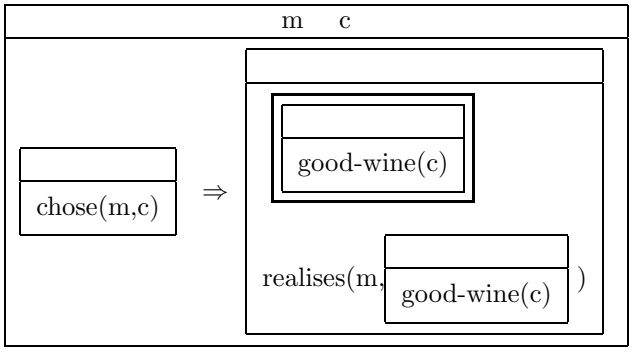
The global DRS is accessible from within the negation. The marker x can be resolved with the marker f, and in this case both the universe of the presupposition (now f) is accessible in the global universe, and the condition in the presupposition is accessible as a global condition. Thus the presupposition has an antecedent. The double-lined presupposition box, which plays no further role in DRS construction, and does not enter into the model theoretic interpretation of the completed DRS structure, is simply removed.

Note that it would make little difference to the treatment of 24 if the word 'somebody' had been replaced by 'he'. Van der Sandt thus provides an interesting twist to the DRT treatment of noun phrase semantics, since in his extended DRT an indefinite (when embedded in a presuppositional environment) can act anaphorically.

Now we come to accommodation. An example will illustrate the power of the accommodation mechanism and at the same time illustrate an analogy that might be drawn between van der Sandt's theory and a transformational account of syntax, van der Sandt's equivalent of *move-α* being an operation on DRSs.

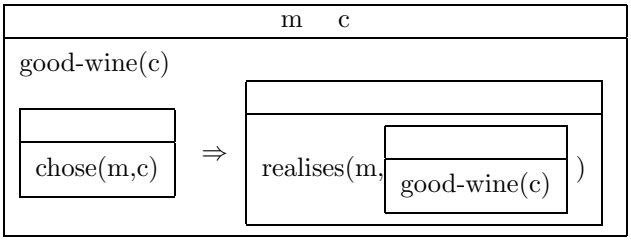
(25) If Mary chose the Chateau Neuf, then she realises it's a good wine.

Assuming, just so that we can concentrate on the treatment of the factive 'realises', that 'Mary' and 'the Chateau Neuf' and 'it' are simply represented as discourse markers, the following DRS is derived:

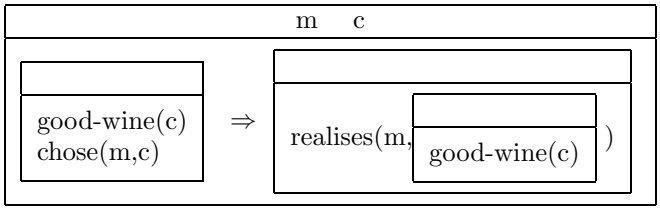


To produce a DRS in which there is no antecedentless presupposition, a transformation must take place whereby α, the presupposition [][good-wine(c)][41], is moved to one of the three sites accessible from the site of the trigger, producing the following three representations:

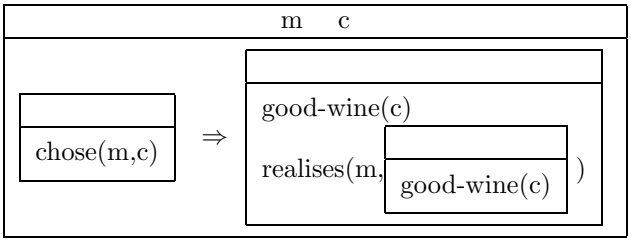
Global Accommodation (Gloss: 'CN is good, and if Mary orders it then she realises it's good.')



Intermediate Accommodation (Gloss: 'If CN is good and Mary orders it, then she realises it's good.')



Local Accommodation (Gloss: 'If Mary orders CN then it's good and she realises it's good.')



Given all these forms of accommodation, and, in van der Sandt's theory, additional options when resolution is possible, how are we to decide which treatment is preferred? Heim offered only one heuristic: "I suggest that the global option is strongly preferred, but the local option is also available in certain circumstances that make it unavoidable."[Hei83a, p.120] Van der Sandt provides much more detail. He offers a number of constraints that any solution must obey, and also

[41] When giving DRSs in the running text, I use a linear notation, whereby [a,b][p(a,b),q(a)] represents a DRS which introduces markers a and b, and has conditions p(a,b) and q(a).

suggests a group of preferences between alternative solutions that satisfy those constraints, including a preference for global over local accommodation.[42] The following versions of the preferences and constraints are at some points revised, but I think capture van der Sandt's intentions[43]:

Definition 30 (Absolute Constraints on van der Sandtian Solutions)

1. *Trapping. If a presupposition containing a discourse marker d is triggered in an environment where d is bound, the presupposition will be resolved or accommodated at a site from where the relevant binding occurrence of d is accessible.*

2. *Global Informativity. If some DRS K is incremented with information from a new sentence, such that after solution of all presuppositions the new DRS is K', then* $K \not\models K'$

3. *Local Informativity. No sub-DRS is redundant. Formally, if K is the complete DRS structure and K' is an arbitrarily deeply embedded sub-DRS, K' is redundant if and only if* $\forall M, f \;\; (M, f \models K \;\; \rightarrow \;\; M, f \models K[K'/\top])$. *Here* $K[K'/\top]$ *is a DRS like K except for having the instance of K' replaced by an instance of an empty DRS, and* $\models$ *denotes the DRT notion of* embedding.

4. *Consistency. No sub-DRS is inconsistent. Formally, if K is the complete DRS structure and K' is an arbitrarily deeply embedded sub-DRS, K' is locally inconsistent if and only if* $\forall M, f \;\; (M, f \models K \;\; \rightarrow \;\; M, f \models K[K'/\bot])$. *Here* $K[K'/\bot]$ *is a DRS like K except for having the instance of K' replaced by an instance of an inconsistent DRS.*

Definition 31 (Preferences Between van der Sandtian Solutions)

1. *Resolution is preferred to accommodation.*

2. *One resolution is preferred to another if the first is more local (i.e. closer to the site of the trigger).*

3. *One accommodation is preferred to another if the first is more global (i.e. further from the site of the trigger).*

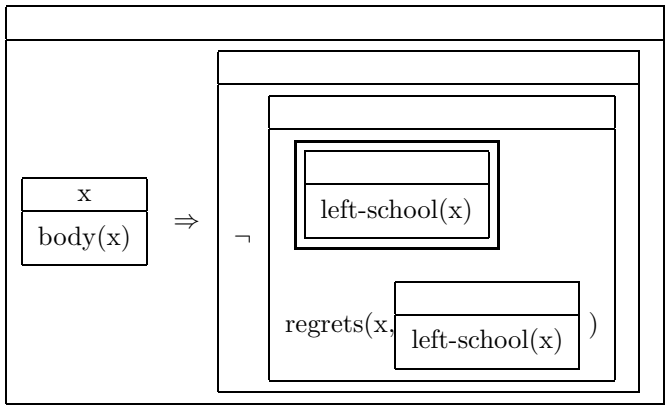
I will illustrate these constraints with some examples. Firstly, trapping:

(26) Nobody regrets leaving school.

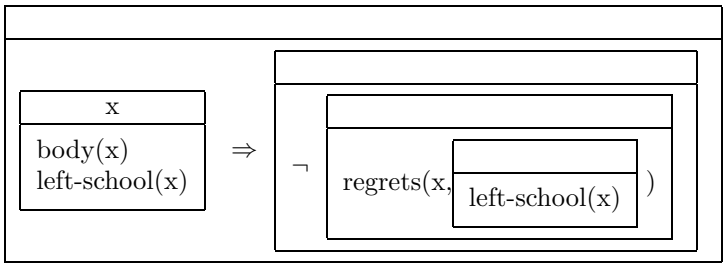
Initially the following DRS might be constructed:

[42] In earlier versions of van der Sandt's theory the preferences between solutions were stated less explicitly, as side effects of a general algorithm for treating presuppositions. This algorithm, which he termed the "anaphoric loop" consisted of the following steps: on encountering a presupposition, firstly check each DRS along the accessibility path from the trigger, moving successively outwards, and attempting to resolve the presupposition, and if after reaching the top box no resolution site has been found, check each box in the reverse direction (i.e. from the top box to the trigger site) attempting to accommodate. Thus resolution is attempted first, and only if that fails is accommodation attempted.

[43] In particular, the presentation of constraints here differs considerably from, for instance, the presentation in [vdS92]. Firstly van der Sandt gives two consistency constraints, but these should both be subsumed under the one constraint given here. Secondly, van der Sandt's formulations of informativity and consistency constraints seem to involve a notion of local entailment of sub-DRSs, although I am not aware of such a notion ever having been formalised. Thus his equivalent of my *local informativity* (given as (iii)a on p.167) is "Resolving [a DRS] K_0 to [produce a new DRS] K_1' does not give rise to a structure in which ... some subordinate DRS is entailed by the DRSs which are superordinate to it". Whilst he does not formalise what it is for a DRS to be entailed by the DRSs which are superordinate to it, the formalisation of local informativity given here, in terms of the standard notion of DRS embedding and a simple syntactic operation on DRSs, hopefully ties up that loose end, and is in the spirit of the definitions used in van der Sandt's formalisation of the notion of *acceptability* in his earlier non-DRT work.



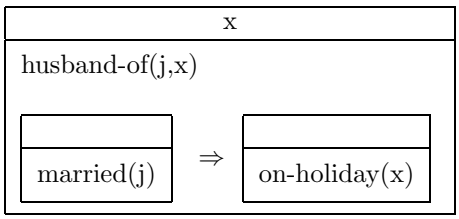
The presupposition cannot be accommodated globally because the discourse marker x would become unbound. The next most preferred accommodation site is in the antecedent box. This produces the final structure, the meaning of which can be glossed as 'Nobody who leaves school regrets having left school':



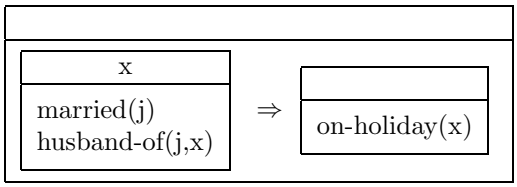
Next, application of the informativity constraint. This is exemplified by 27:

(27) If Jane is married then her husband is on holiday.

Global accommodation of the presupposition that Jane has a husband (triggered by 'her husband') would produce the following DRS:



But, on the assumption that models are constrained by meaning postulates in such a way that if somebody has a husband then they are married, this DRS breaks the informativity constraint: replacing the DRS in the antecedent of the conditional, [][married(j)], by the empty DRS [][] would not alter the range of models in which the global DRS could be embedded. Thus, once again, intermediate accommodation is preferred, producing a structure glossable as 'If Jane is married to x, then x is on holiday':



The next two examples, which I will not discuss in detail, illustrate the consistency and global informativity constraints, respectively:

(28) Either Jane is a spinster, or else her husband is on holiday.

(29) Jim is Fred's friend, and Fred is married. He is married too.

The reader should verify that for 28, the consistency constraint prevents global accommodation of the presupposition that Jane is married, forcing local accommodation, and that for 29 the global informativity constraint prevents resolution of the variable associated with 'he' to the discourse marker for Fred.[44]

Van der Sandt's DRT-based model of presupposition gets right the cases which Gazdar's theory handles well (i.e. where presuppositions are either explicitly denied, or appear to be outcompeted by implicatures) *and* the cases which Karttunen's theories handle well (typically where a presupposition is entailed in its local context). Note that below in §5.1 a combined Gazdar-Karttunen theory is presented, following work of Soames, which is comparable to van der Sandt's DRT-based model in this respect. However, *none* of the cancellation accounts discussed, *none* of the various theories proposed singly or in joint work by Karttunen, and *neither* the combined Gazdar-Karttunen theory *nor* Soames own combined model provides an adequate account *either* of presupposed open propositions and their interaction with quantifiers, *or* of Kripkean cases of anaphoric presupposition. Van der Sandt's model treats both of these phenomena.[45].

4.6 Accommodation as Context Selection

Accommodation may be thought of procedurally, as an algorithmic repair strategy for mending discourse representations in the face of presupposition failure. This is how the first versions of van der Sandt's DRT theory were presented (but see [SG91]), and how the approach to accommodation presented by Fauconnier (see §5.5, below) is conceived. The current section concerns a declarative treatment of accommodation. This treatment extends the CCP model in a way related to proposals I have made elsewhere [Bea92, Bea95, Bea:MS]: here I beg the reader's forgiveness for my self-indulgence. In the extended model, accommodation is not naturally thought of as a repair strategy, but as a normal part of the communicative process whereby hearers monotonically gain information about speakers' beliefs.

In order to communicate effectively a speaker must make some assumptions about the common ground of information between the conversational participants, to take some information for granted. Presuppositions can be taken to reflect the assumptions about the common ground that the speaker has made (or, sometimes, wishes to appear to have made). The common ground assumed by the speaker can be modeled as a Stalnakerian context, a set of worlds, but a hearer cannot know which set of worlds this is. So a hearer's information about the speaker's assumptions can be modeled, so as to incorporate this uncertainty, as a set of Stalnakerian contexts. These contexts, all those which *might* accord with the speaker's assumptions, will be termed *epistemic alternatives*, and a set of *epistemic alternatives* will be called an *alternative set*. When a new sentence is uttered, with accompanying presuppositions, the hearer learns more about the speaker's

[44]Note that in van der Sandt's system pronouns are treated in the same way as standard presupposition triggers, except that the presupposed DRS associated with a pronoun (something like [x][]) is assumed to contain insufficient conditions to support accommodation.

[45]For further critical discussion of van der Sandt's DRT account see [Bea95, Bea94b] For extensions to the theory, see Saebo's [Sa94] and Geurts' [Geu95]

assumptions, and is able to eliminate — 'filter out' — those epistemic alternatives which cannot correspond to the speaker's assumptions. Those alternatives which remain after this filtering must be updated with the information in the new sentence, and this produces a new alternative set to use when the next sentence is uttered. In this way, both presuppositions and assertions may be informative, although they inform on different levels: whereas assertions, following Stalnaker, are understood as filtering worlds, presuppositions filter sets of worlds.

In the following three definitions, Σ ranges over alternative sets (so $\Sigma \in \mathcal{P}(\mathcal{P}(W))$), and a notion of update of an alternative set with a PrL formula, $\Sigma + \phi$, is defined in terms of the earlier CCP semantics (definitions 20, 21 and 23). Note that the definition of the update function "+" is given in terms of the $[\![.]\!]$-relation by a standard 'lifting' technique, the so-called *subset* construction (c.f. the discussion in Fernando's [Fe95]). Satisfaction of a formula relative to an alternative set $\Sigma \models \phi$, as at the lower CCP level, is given by a fixed-point construction. Finally a notion of entailment is given, whereby ϕ entails ψ relative to an alternative set Σ if the update of Σ with ϕ satisfies ψ.

Definition 32 (Accommodating Update, Satisfaction and Relativised Entailment)

$$\begin{array}{rcl} \Sigma + \phi & = & \{\tau \mid \exists \sigma \in \Sigma \tau [\![\phi]\!] \sigma\} \\ \Sigma \models \phi & \textit{iff} & \Sigma + \phi = \Sigma \\ \phi \models_\Sigma \psi & \textit{iff} & \Sigma + \phi \models \psi^{46} \end{array}$$

To see how this approach to accommodation might be applied, consider the following two examples containing the factive 'the knowledge that', both of which have the general form $\phi \rightarrow \psi_\pi$:

(30) If David wrote the article then the knowledge that no decent logician was involved (in writing the article) will confound the editors.

(31) If David wrote the article then the knowledge that David is a computer program running on a PC will confound the editors.

Both examples have the general form $\phi \rightarrow \psi_\pi$. Yet the examples contrast in terms of the assumptions that a speaker would presumably be making. For example 30 the conditional presupposition $\phi \rightarrow \pi$ predicted by the CCP model, i.e. that if David wrote the article then no decent logician was involved, is easily defensible. However, for 31 some might say that the presupposition that David is a computer program simply projects, and is not conditionalised. Within the context selection model such a contrast may be predicted, whilst still allowing that the underlying presupposition is a conditional. Suppose firstly that it is plausible that David is not a good logician, so that the conditional 'if David wrote the article then no decent logician was involved', that is $\phi \rightarrow \pi$, is also quite plausible. Then we might expect some epistemic alternatives to include this information. It is easily verified that relative to an alternative set Σ which contains such alternatives, $\phi \rightarrow \psi_\pi$ entails $\phi \rightarrow \pi$, but does not entail π. So for the first example the conditionalised presupposition emerges (albeit as an entailment, since I have not here defined a notion of presupposition relative to an alternative set). Now the second example. Reinterpreting π as 'David is a computer program running on a PC', it can be argued that whilst it is *a priori* plausible that π holds, a speaker is unlikely to assume the conditional that David is a computer program if he wrote the article, i.e. $\phi \rightarrow \pi$, without assuming π itself. Relative to an ordering which contains alternatives where π holds, but in which for all alternatives where π does not hold $\phi \rightarrow \pi$ also does not hold, we will have that $\phi \rightarrow \psi_\pi$ entails π, but does not entail $\phi \rightarrow \pi$. Thus it can be seen that under certain quite strong assumptions about what is intrinsically plausible, the context selection model may predict that a conditionalised presupposition is effectively strengthened, as if the embedded presupposition had projected in the first place.

A few remarks are in order. Firstly, a sharp cut-off line between plausible and implausible alternative sets is difficult to justify. For this reason in the full model, such as discussed in [Bea95, Bea:MS], the set of alternatives is replaced with an ordering over alternatives. It is then only necessary to justify that some alternatives are more plausible than others, and not that some

are inherently so implausible that they are not even considered. Secondly, note that whatever the shortcomings of the simple context selection model presented here, it does at least allow both for embedded presuppositions becoming full entailments and for presuppositions remaining only in weak conditionalised form. A model which does not allow for any conditionalised presuppositions, such as the cancellation and filtering models, will have difficulty with examples like 30, of which we will see yet more variants shortly. Note that the context selection model may be thought of as an attempt to cash out the suggestion by Karttunen and Peters [KP79] that conditionalised presuppositions may sometimes be strengthened by conversational implicatures.[47]

5 Syntheses

Theories of presupposition continue to proliferate. It is rarely clear what the relationship between different theories is, and not always easy to say whether progress is being made either technically or descriptively. In fact there has been both technical convergence and an increasing amount of agreement as to what the central problems are. Indeed, one of my primary aims in writing this chapter has been to show the great extent to which convergence and synthesis have already occurred within what is apparently a quite disparate field, as well as hopefully demonstrating of the possibility of such unifying development in the future. The very fact that it has been possible to present different theories in a relatively uniform format — albeit that this sometimes involved riding rough-shod over the philosophical proclivities of the original authors — shows many of the differences between theories to be superficial. To cite a particular case of convergence in what has been discussed, observe van der Sandt's use within a cancellationist account of Karttunen's notion of local context (c.f. §3.3).[48] Or observe the various similarities between the theories of Heim and van der Sandt that have been discussed. In this section we will consider a number of other ways in which theories can be compared from a technical viewpoint, or new theories synthesised.[49]

5.1 Cancellation and Filtering

The cancellation and filtering theories are largely complementary in terms of which data they get right. Having observed this complementarity, Soames [So82] proposed a synthesis of Gazdar's account with the later versions of Karttunen's account in [Kar74, KP79]. However, as mentioned earlier, the later versions of Karttunen's theory are not filtering theories in the sense defined above. The presuppositions that a complex sentence is predicted to have are not a subset of the

[47] For criticism of Karttunen and Peters, and of the context selection model, see Geurts' [Geu95], and for yet more discussion see [Bea94b].

[48] Van der Sandt's later DRT account also has dynamic features reminiscent of Karttunen's proposals. The dynamics of the DRT account can be said to reside in at least three aspects of the theory: the (extended) DRS construction algorithm, the standardly dynamic DRT semantics of implication and quantifiers, and the statement of anaphoric accessibility conditions. The notion of accessibility is implicitly directional, in that it is invariably defined using an anti-symmetric relation, and reflects Karttunen's conditions on context incrementation. We might restate accessibility conditions in a way that brings this out. Say that a DRS α is a pair $\langle \alpha_0, \alpha_1 \rangle$, with α_0 a set of discourse markers and α_1 a set of conditions. Define $var(\alpha)$ as the set of markers mentioned in the conditions α_1, and take the context σ of any sub-DRS to be a set of discourse markers: this should be thought of as the set of markers external to a DRS which are accessible from within it. The markers of a DRS α in a context σ are completely accessible, written $\sigma \succ \alpha$, if $var(\alpha) \in \alpha_0 \cup \sigma$. Then the following two rules state whether the variables in the sub-DRSs of negations and implications are accessible:

$$\sigma \succ \alpha \to \beta \quad \text{iff} \quad \sigma \succ \alpha \ \textit{ and } \ \sigma \cup \alpha_0 \succ \beta$$
$$\sigma \succ \neg\alpha \quad \text{iff} \quad \sigma \succ \alpha$$

These rules, which must be extended to allow for van der Sandt's notion of accessibility of DRS conditions as well as DRS markers, are obviously close to Karttunen's admissibility conditions, as given above (definition 17), although differences will arise with conjunction and disjunction. See Zeevat's [Ze92] for a reformulation of van der Sandt's DRT account which truly brings out the similarities with dynamic theories in the Karttunen-Heim tradition.

[49] It is arguable that the degree of convergence runs deeper than is detailed here. For instance, I give no direct comparison between multivalent and cancellationist accounts of presupposition. In fact there are now a number of theories which model the defeasibility of presuppositions using non-boolean semantic valuations, such as those of Schöter [Schö95, Schö:MS] and Marcu [Ma94].

potential presuppositions of its parts. This complicated Soames' attempt to unify the insights of the two account in a single theory. To give an idea of the difficulties faced, ask yourself this question: when looking for a synthesis between two accounts, where the first account makes all presuppositions members of the set of potential presuppositions, and the second account does not, should the resulting theory be expected to make all presuppositions members of the set of potential presuppositions? (Soames in fact answers in the negative.)

A much simpler integrated theory, but one which still preserves Soames' central insight, could be formed by combining the Karttunen 1973 theory, as discussed above, with Gazdar's. The most obvious way to join the two theories so as to address both defeat of presuppositions by inconsistency and filtering of presuppositions which are locally entailed, would simply be to take the intersection of the set of presuppositions predicted by each of the two models. One would need first to strip the epistemic operators from Gazdar's presuppositions, or add such operators to Karttunen's, but I take this to be a trivial task. It would be natural to identify Karttunen's set of assumed facts with the incoming context in Gazdar's model. Such a joint Gazdar-Karttunen model provides a formidable account of presupposition, combining relative simplicity with a clear improvement over the original cancellation and filtration accounts (as will be seen in §6.3).

5.2 Trivalent and Dynamic Semantics

The thesis, descending from the work of Frege and Strawson, that presupposition projection should be explained as inheritance of semantic undefinedness, seems to find an antithesis in the suggestion that presupposition projection arises from (pragmatically justified) principles of context change. However, Peters, in [Pe77], provided a synthesis, observing that the presupposition inheritance properties derived in [Kar74] could be duplicated in a system with a trivalent semantics, and thus do not depend on the dynamicity of Karttunen's account. The connectives in Peter's trivalent system, which I will refer to as the *Peters' connectives* (but which Krahmer [Krah93] terms the *Middle Kleene* connectives), can be used to show the relationship between the dynamic logics developed in the current work and trivalent logics. Note that the correspondence breaks down once we move to a quantificational logic, since the dynamic systems discussed manifest quantifier-scope properties not found in any standard trivalent system.

The Peters' connectives may be likened to the strong Kleene connectives, except that if the left-hand formula under a binary Peters' connective is undefined, then the whole formula is undefined:

Definition 33 (The Peters' Connectives) *The 3 valued interpretation of a complex formula ϕ relative to a world w, written $[\![\phi]\!]^3_w$, is given by recursion over the following truth tables:*

$\phi \wedge \psi$	t	f	$\star$
t	t	f	$\star$
f	f	f	f
$\star$	$\star$	$\star$	$\star$

$\phi \vee \psi$	t	f	$\star$
t	t	t	t
f	t	f	$\star$
$\star$	$\star$	$\star$	$\star$

$\phi \rightarrow \psi$	t	f	$\star$
t	t	f	$\star$
f	t	t	t
$\star$	$\star$	$\star$	$\star$

ϕ	$\neg\phi$
t	f
f	t
$\star$	$\star$

The following definitions and facts than establish that notions of entailment in the three valued and dynamic systems coincide extensionally. It follows as a corollary that definitions of presupposition in terms of entailment also coincide for the two systems.

Definition 34 (Entailment in the 3-valued system) *Let $[\![\phi]\!]^w_3$ be defined using the Peters' connectives and the trivalent interpretation of the presupposition operator given in definition 7. Then trivalent entailment is given by:*

$$\phi \models_3 \psi \quad \textit{iff} \quad \forall w \in W, [\![\phi]\!]^w_3 = t \;\Rightarrow\; [\![\psi]\!]^w_3 = t$$

Definition 35 (Entailment in the Update System) *Let* $[\![.]\!]_u$ *be as in* $[\![.]\!]$ *of definitions 20, 21 and 23. Then dynamic entailment is given by:*

$$\phi \models_w \psi \quad \textit{iff} \quad \forall \sigma \subseteq W\ \sigma[\![\phi]\!]_u\sigma\ \rightarrow\ \sigma[\![\psi]\!]_u\sigma$$

Fact 36 $\phi \models_3 \psi$ *iff* $\phi \models_w \psi$ *A proof is given in [Bea95].*[50]

5.3 From Cancellation to Accommodation

Accommodation provides one of the great unifying themes of modern presupposition theory, since many theories of presupposition which were not originally proposed as accommodation theories can be thought of in terms of accommodation. In a sense cancellation is the inverse of global accommodation. Heim [Hei83a], after suggesting her enhancement of the CCP model with an account of accommodation, makes the following observation:

> Note that by stipulating a *ceteris paribus* preference for global over local accommodation, we recapture the effect of [Gazdar's] assumption that presupposition cancellation occurs only under the threat of inconsistency.

I find this stunning. With one short remark buried in a terse paper Heim offers a simple synthesis between the two antitheses of 1970's presupposition theory, namely the Karttunen 1974 derived model which her paper uses as its base, and Gazdar's cancellation account. Perhaps implicit in Heim's remark is the idea that global accommodation of an elementary presupposition may be identified with what was termed *projection* in earlier models. In this case whenever accommodation is not global, we have the effect of cancellation. Looked at this way, a preference for global over local accommodation becomes a preference for projection over cancellation, and given an appropriate stipulation of the circumstances in which this preference can be overridden (e.g. in order to avoid inconsistency), the effects of a cancellation theory can be mimicked. In a stroke this shows a way to eliminate the bulk of existing counter-examples to the CCP model, in particular examples where a presupposition associated with an embedded trigger is eliminated by explicit denial. Further, and in common with van der Sandt's cancellation account, Heim's remark introduces a way of thinking about Gazdar's theory that preserves his insight that default reasoning is involved in the processing of presuppositions, whilst restoring the intuition that, in some sense, presuppositions are to do with *what come first*, with definedness conditions on the input rather than preferences on the output. Note that in [vdS88] van der Sandt is explicit in identifying his cancellation analysis as involving an accommodation-like mechanism, although this was not the case in his theory's first incarnation [vdS82]. Also note that for Heim's analogy between cancellation and accommodation theories to really drive home it is important that in the cancellation account it is assumed that presuppositions are also part of the asserted content. Entailment of presuppositions is what produces the effect of local accommodation in cases where the presupposition is globally canceled.

5.4 The Transformation from Russell to van der Sandt

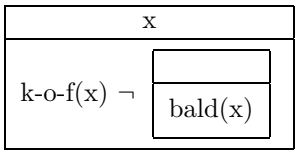
Now let us consider a very different type of theory, that of Russell, in which alternative presuppositional readings are obtained only as a result of variations in logical scope. Strangely, these scopal variations are mirrored by the alternative accommodation readings in van der Sandt's theory, save that Russell's logical forms happened to be expressed in FOPL, whereas van der Sandt's are expressed in the language of DRT. Russell gave few hints as to how his logical forms should be derived, and I see no obvious reason why a Russellian theory of scopal variation should not be developed where scope bearing operators are initially interpreted *in situ* to produce a first logical form, and are then moved about to produce the final logical form in a manner reminiscent of the

[50] The proof in [Bea95] concerns a system with a unary connective ∂ instead of the binary presupposition connective. However, the systems are interdefineable, with $\phi_\psi =_{\text{def}} \phi \wedge \partial\psi$, so the proof carries over directly.

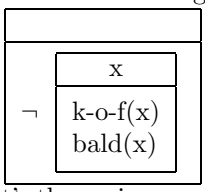
semantic *move-α* operations of van der Sandt's theory.[51] Thus we see that the transformation from Russell to van der Sandt is surprisingly small.

For instance, a neo-Russellian and van der Sandt accounts allow essentially the same two readings for sentences like 'The King of France is not bald.' Taking 'ι' to be a Russellian definite description operator, the Russellian narrow scope negation reading can be represented as ιx[k-o-f(x)](¬bald(x)). Corresponding to this is the van der Sandtian global accommodation reading in (a), below. On the other hand the neo-Russellian wide-scope negation reading, ¬(ιx[k-o-f(x)](bald(x))), is analogous to van der Sandt's local accommodation reading, in (b).

(a)



(b)



But this is not to deny that van der Sandt's theory incorporates important innovations. Firstly, van der Sandt's account includes not only an accommodation component, but also an anaphoric resolution component completely alien to the Russellian picture of definites. The importance of incorporating anaphoricity is discussed in §6.1, below. Secondly, van der Sandt not only allows for presuppositional elements to take different *scopes*, he also provides an account of which scopes are to be preferred, and this is again something absent from the Russellian account. Thirdly, and specifically as a result of being situated in DRT, van der Sandt's model allows for extra possibilities which would not be available to Russell. For instance, a presupposition α triggered in the consequent of a conditional may, in van der Sandt's theory, eventually make its way to the antecedent of the conditional. Such a transformation would make no sense on the Russellian picture, since an element in the antecedent of a conditional could classically not bind material in the consequent.

5.5 Accommodation as a Journey through Mental Space

Fauconnier [Fa85] presents a representationalist theory in which meanings are rendered in a structured collection of interconnected *mental spaces*. Mental spaces are akin to Kamp's DRS boxes (or, perhaps even more aptly, Seuren's *discourse domains*).[52]

In order to see what Fauconnier's theory of presupposition [Fa85, pp.86–87] would look like in a van der Sandtian setting, let us assume that a space is just a DRT box (i.e. a set of discourse markers and a set of conditions), and assume a DRT-like notion of accessibility. Let us say that a proposition is *supported* in a space if it is a consequence of the conditions in that space, and

[51] For formulations of Russellian theories of presupposition, see the work of Delacruz [Dela76], Cresswell [Cr73, pp.168-169] and Grice [Gr81]. Also relevant is Neale's [Ne90], although this does not target presupposition *per se*. Kempson [Kem75, Kem79], Wilson [Wi75] and Atlas [At76, At77], whilst holding in common with Russell that there is no special presuppositional component to meaning, provide forceful arguments against the Russellian explanation of presuppositional inferences in terms of scope.

[52] A few remarks should clarify the similarity with DRT:

1. Like DRS boxes, mental spaces can be seen as partial models in which a set of discourse entities bear certain properties and relations to each other, but in which the extensions of many other properties and relations are left undecided.

2. Like DRS boxes, mental spaces are arranged hierarchically, with some boxes being seen as subordinate to others. Properties of objects in subordinate *daughter* spaces may be inherited from their *parent* spaces. However, the links between entities in different spaces are not sustained by variable binding, but by a Lewisian counterpart relation. The inter-space links between entities are analogous to the connections between discourse markers in later versions of DRT [KRe93] where objects in intensional contexts are linked to objects outside by *anchoring* functions, these determining which objects are counterparts of which others.

3. Unlike Kamp, Fauconnier does not follow the Montagovian method of fragments. He does not provide a fully formalised method of constructing mental spaces for all the strings produced by a generative grammar.

4. Unlike in DRT, no semantic interpretation or Tarski truth definition is given for mental spaces, and no notion of logical consequence between mental spaces is defined.

that a proposition is *accessible* from a space if it is a consequence of propositions in accessible (i.e. superordinate) spaces, and let us assume a standard logical definition of *consistency* of a space, meaning consistency of the set of conditions in that space.[53] In certain cases (generally non-intensional contexts) Fauconnier also employs a notion of *compatibility*, meaning consistency of the set of conditions either in the space or accessible from it. Fauconnier's theory of presupposition can be described as a theory of presupposition flotation, whereby locally triggered presuppositions float up through as many spaces as they can without creating inconsistency.[54] I would characterise the theory as follows:

1. Presuppositions must be supported in the local space of the trigger.
2. If a presupposition is accessible, then nothing further need be done.
3. Otherwise, the presupposition is accommodated into successively more global spaces along the accessibility path, until reaching the highest space where accommodation does not create inconsistency at the accommodation site, or incompatibility of any (non-intensional) subordinate space.[55]

It is readily seen that, at least in the van der Sandtian form that I have presented it, Fauconnier's model will make predictions comparable to some of the other models that have been discussed. The first clause means that in a sense Fauconnier always locally accommodates, whatever else he does. This produces the effect that in a cancellation account would be derived by assuming presuppositions to be part of the asserted content. The second clause provides for something like van der Sandt's anaphoric resolution of presuppositions. In most cases this will presumably yield filtering of entailed presuppositions as in Karttunen's '73 model. The third clause meanwhile will prevent global accommodation in case that would produce inconsistency, thus giving the effect of a cancellation theory in cases of presupposition denial.[56]

6 Empirical Issues

6.1 Anaphoricity

Over the last decade a number of authors, notably van der Sandt [vdS89, vdS92], Kripke [Krip:MS] and (following Kripke) Soames [So89], have argued that there is a tight connection between presupposition and anaphora. Van der Sandt has pointed out that for every example of what might be called *discrepant anaphora*, by which I mean those cases where the anaphoric link is not naturally treated using standard binary quantifiers to interpret determiners and bound variables for pronouns, parallel cases of *discrepant presupposition* can be found. To exemplify this parallelism, I give the four triples below. The (a) examples exemplify discourse anaphora, donkey anaphora, bathroom sentences and modal subordination, respectively. In each case, a corresponding example is given, as (b), in which a presupposition is triggered (by the adverb 'still') in the same structural position as the anaphor occurred, but in which this presupposition is satisfied. The third member, (c), completes the circle, showing that the argument of the presupposition trigger can itself be pronominalised with no change of meaning.

[53] The relation *supports* corresponds approximately to Fauconnier's *satisfaction*, but I refrain from using this term here since I have tended to use it elsewhere with a slightly different meaning. I have also been rather cavalier with Fauconnier's notion of *accessibility* of a proposition. I have assumed that propositions in all superordinate spaces are accessible, but Fauconnier is interested in a wide variety of intensional contexts such that (consequences of) propositions holding in parent spaces cannot in general be expected to hold locally.

[54] The flotation metaphor is used by Fauconnier himself. Coincidentally, the same metaphor is chosen by Geurts [Geu95] when discussing van der Sandt's accommodation theory.

[55] I take the *incompatibility* requirement from Fauconnier's discussion of conflicting presuppositions in disjunctions [Fa85, p.92].

[56] Other theories of presupposition that can be compared with van der Sandt's in much the way as Fauconnier's are those of Dinsmore [Di81b, Di92], and Schiebe [Schi79]. Like the theories of van der Sandt and Fauconnier, these accounts are explicitly procedural, and explicitly representational.

(32) a. A farmer owns a donkey. He beats it.
b. Wanda used to beat Pedro. She still beats him.
c. Wanda used to beat Pedro. She still does.

(33) a. If a farmer owns a donkey then he beats it. [*Geach*]
b. If Wanda used to beat Pedro then she still beats him.
c. If Wanda used to beat Pedro then she still does.

(34) a. Either there is no bathroom in this house or it's in a funny place. [*Partee*]
b. Either Wanda never beat Pedro, or she still beats him.
c. Either Wanda never beat Pedro, or she still does.

(35) a. Perhaps a wolf came to the door. Perhaps it ate Granny.[*Adapted from Roberts*]
b. Perhaps Wanda used to beat Pedro, and perhaps she still beats him.
c. Perhaps Wanda used to beat Pedro, and perhaps she still does.

The parallel is compelling, and furthermore similar examples are easily constructed involving all standard presupposition types. But evidence for the anaphoricity of presuppositions goes beyond cases where the presupposition is satisfied because it is in some sense anaphoric on a textual antecedent. The reverse of the coin is that, for at least some types of presupposition trigger, if a textual antecedent is not present the presupposition *cannot* be satisfied. Kripke observes that a common analysis of 'too' would make the presupposition of sentence 36, below, the proposition that somebody other than Sam is having supper in New York tonight. However, this proposition seems uncontroversial, so the standard account provides no explanation of why the sentence, uttered in isolation, is infelicitous.

(36) Tonight Sam is having supper in New York, too. [Krip:MS]

Notably, 36 is felicitous when it follows a sentence saying of somebody other than Sam that he is having dinner in New York tonight, e.g. 'Saul is having dinner in New York tonight.' It might be argued that 36 places a requirement on its local context that there is a salient having-supper-in-NY-tonight event. Although one could imagine introducing event discourse markers, and some ontology of events, into the framework we have sketched so far, less effort will be required if we restrict ourselves to an alternative suggestion in Heim's [Hei90]. This is the hypothesis that 36 is felicitous in contexts where there is a discourse entity of which it is locally satisfied that the entity is having supper in New York tonight. Adapting from Heim somewhat, we might give the following sketch of an admittance condition for formulae ϕtoo_i:

Definition 37 (Heimian 'too')

$$\sigma[\![\phi too_i]\!]\tau \quad \textit{iff} \quad \sigma[\![\phi]\!]\tau\textit{, and there is some index } j \textit{ such that } \sigma \models \phi[i/j]$$
$$\textit{(where } \phi[i/j] \textit{ represents } \phi \textit{ with all instances of } x_i \textit{ replaced by } x_j\textit{)}$$

If 36 were indexed 'Tonight Sam$_i$ is having supper in New York, too$_i$', its translation would only be admitted in contexts where for some j, the translation of 'Tonight x_j is having supper in New York' was satisfied. We would thus expect 36 only to be admitted in a restricted range of contexts, but 'If Saul is having supper in New York tonight, then Sam is having supper in New York, too.' to carry no presupposition at all.

Perhaps it can be imagined how analyses like that for 'too' above could be given for other presupposition types. For instance, to make factives anaphoric, one might introduce discourse markers for propositions and facts, a development which would anyway be essential to treat propositional anaphora within texts (c.f. [As93]). One could then make acceptability of a factive verb with propositional complement ϕ conditional on the presence of a *factual* discourse marker, e.g. a discourse marker identifying a proposition satisfied in the local context.

For which presupposition triggers is an anaphoric analysis actually appropriate? Van der Sandt, in his DRT account, gives a straightforward answer: all presupposition triggers are anaphors. That is to say, at the level of discourse representation all presupposition triggers must have an anaphoric antecedent. Note, however, that although van der Sandt provides a model in which 'too', in common with other triggers, can act anaphorically, this is not yet sufficient. For requiring an antecedent at the level of discourse representation is much weaker than requiring a strict textual antecedent. Van der Sandt's mechanism of accommodation will always be able to build an antecedent for a given occurrence of 'too', so an explicit textual antecedent is unnecessary. Yet this runs contra to the well established fact [So89] that in most cases an occurrence of 'too' does require an explicit textual antecedent. A sentence like 36 would make a strange start to a conversation. To get the facts right, van der Sandt would have to modify his model by removing the option of accommodation for 'too', and allowing only simple resolution and partial match. This would not be technically difficult, but it would seem unmotivated. Here those familiar with van der Sandt's account might recall the explanation he gives of why ordinary pronouns require a textual antecedent: he says that they lack the descriptive content which accommodation requires. But in the case of 36 we have nontrivial information about the antecedent, corresponding to the DRS [x][not-sam(x),having-supper-in-ny-tonight(x)]. So whilst van der Sandt's explanation of why accommodation is not triggered by pronouns seems plausible, it would wear thin if applied to the case of 'too', although one would think that the explanations for non-accommodation by pronouns and non-accommodation by 'too' should be similar.[57] Perhaps van der Sandt's theory could be improved by not treating the class of presupposition triggers uniformly in the first place, but by actually making a separation of anaphoric and non-anaphoric triggers: an argument for this move, which anyway fits well into the fabric of van der Sandt's account, is given in §6.2, below.

To conclude this section, let me point out that there is one rather common-place phenomenon which nicely demonstrates the anaphoricity of presupposition whilst confounding all the theories discussed in this chapter. This is the phenomenon of bridging. Consider the following:

(37) Whenever a ship docks, the captain always waves.

(38) As Hermione drove along the dark road, every bend presented a danger.

(39) If I go to a wedding the rabbi always gets drunk.

(40) An old woman hit me. The knuckle-duster bit deep.

In the first of these examples, the so-called *bridging description* 'the captain' would seem to be anaphoric on 'a ship'. In this particular case, one can argue that lexical information associated with the common nouns is helping provide the link, 'captain' being an inherently relational noun. One might imagine somehow stipulating that apart from when 'captain' is used with an explicit possesive clause such as 'the ship's captain' or 'the captain of the ship', the presence of a ship is presupposed, and this allows a link to be made. Example 38 demonstrates that the phenomenon is not restricted to definites, since here the domain restriction of a quantifier appears limited to bends in a contextually salient road. But once again, it could at least be argued that 'bend' is a relational noun, and perhaps some sort of explanation could be constructed without departing too far from existing ideas in presupposition theory. But for the following two cases, such an approach is inappropriate, since neither 'rabbi' nor 'knuckle-duster' (U.S. 'brass-knuckles') would appear to be a relational noun. It seems that when we determine on what a definite NP is anaphoric, we cannot rely only lexical information. The process linking 'rabbi' to 'wedding' must involve quite general inferencing procedures utilising considerable amounts of world knowledge, e.g. to determine whether it is plausible that the speaker only goes to weddings where there is a rabbi. As for 40, whilst 'the knuckle-duster' is perhaps best classified as a bridging description, it is not

[57] Perhaps the real explanation should not be thought of in terms of limitations of the accommodation mechanism, but to do with the function of anaphoric elements themselves. If one of their chief functions were to establish textual coherence, for instance, then they could normally only achieve that goal by linking entities which had actually been mentioned. The need for accommodation would then be a sign of the failure of the text to cohere adequately. See Zeevat's discussion in [Ze94].

even very clear what its antecedent is. The old woman, perhaps? But then, why is it that 'An old woman fell over. The knuckle-duster bit deep.' is so much more difficult to process? Maybe the antecedent is not the woman, but the hitting event? Whatever the best answer, no current theory of presupposition is of much help.[58]

6.2 Accommodation and the Taxonomy of Triggers

I would like to highlight one respect in which the version of Fauconnier's theory above clearly makes different predictions from van der Sandt's DRT account. Under Fauconnier's accommodation strategy, as a presupposition floats upwards it leaves a shadow behind (i.e. a copy of the presupposition) in every space through which it passes. But van der Sandt's strategy depicts presuppositions as bubbling up without leaving any trace of their journey. In fact Zeevat has compared an accommodation strategy just like Fauconnier's to van der Sandt's, although Zeevat attributes what I call Fauconnier's strategy to Heim. Distinguishing the two strategies Zeevat says [Ze92, p.396]: "The one remaining difference [i.e. between his version of van der Sandt's theory and his version of Heim's theory] is the question whether we should add the presupposition everywhere between the position of the trigger and the highest position where it can be accommodated, or whether we can be satisfied with adding it just once at that position." So which is the right strategy? Zeevat comes to an interesting conclusion: both are right, but for different classes of presupposition trigger. The two classes Zeevat delimits are what he calls *anaphoric* and *lexical* presuppositions. The anaphoric (or *resolution*) triggers are those "whose primary function is — like anaphora — to collect entities from the environment in order to say new things about them."[Ze92, p.397] This class, which presumably at least includes definite noun phrases, and discourse particles like *too* and *again*, is the one for which Zeevat supposes the van der Sandtian strategy to be appropriate. The following data back up his point:

(41) a. Bill called Mary a Republican. And it is clear from Mary's diary that John insulted her too.

b. It is clear from Mary's diary that Bill insulted her.

(42) a. Bill called Mary a Republican. And it is clear from Mary's diary that Bill thinks that John insulted her too.

b. It is clear from Mary's diary that Bill insulted her.

c. It is clear from Mary's diary that Bill thinks he insulted her.

In Zeevat's terms, the *too* in 41(a) and 42(a) is used because the speaker is collecting up a property which he takes to already be realised in the context, the property of insulting Mary, and saying something new about the extension of that property. I would say that on hearing either 41(a) or 42(a) a hearer would normally conclude that the speaker thinks that Bill insulted Mary, presumably in the act of calling her a Republican. So it would seem that 'Bill insulted Mary' — or the proposition that the event of Bill calling Mary a Republican is identical to an event of Bill insulting Mary — is globally accommodated. But (and I hope readers can convince themselves of this) I do not think that on the basis of 41(a) a hearer would conclude that the speaker believes 41(b). This is just what would be predicted on van der Sandt's strategy, since the local context to the trigger, the mental space set aside for what is clear in Mary's diary, would not need to contain the presupposition. Similarly, I do not think a hearer of 42(a) would normally infer that the speaker believes either of 42(b) or 42(c), although these propositions are certainly compatible with what the speaker has said. Thus the presupposition arguably skips over both the space assigned to what Bill thinks in Mary's diary, and the space assigned to what is clear in Mary's

[58]Some cases of bridging, those like 37, have been discussed in the literature. See e.g. Bos *et al*'s [BBM95]. The systems proposed by Hobbs and co-workers [HSAM90] probably come closest to dealing with bridging examples like those above, allowing world knowledge to be used when determining the connections between objects introduced in a text. C.f §4.6 and for more on the importance of world knowledge and common-sense reasoning.

diary, just as van der Sandt predicts. On the other hand, on Fauconnier's strategy both 42(b) and 42(c) would be inferred.

The *lexical triggers* are those where the presupposition is a condition on the application of a concept, so that the presupposition must hold in any context where the trigger is applied if the application of the concept is to be meaningful. Factive verbs are presumably in this class. From the definition of lexical triggers, we can see that the presupposition should be expected to hold not only at the highest accommodation site, but also locally. Zeevat goes further in requiring lexical presuppositions to hold Fauconnier fashion in all the intermediary contexts, but the following examples perhaps provide some support for this analysis:

(43) a. Bill called Mary a Republican. And it is clear from Mary's diary that she realised that he had insulted her.

b. It is clear from Mary's diary that Bill insulted her.

(44) a. Bill called Mary a Republican. And it is clear from Mary's diary that Bill thinks she realised that he had insulted her.

b. It is clear from Mary's diary that Bill insulted her.

c. It is clear from Mary's diary that Bill thinks he insulted her.

That 43(b) follows from 43(a) seems indisputable. 44(a) is obviously a more complicated case, and requires considerably more effort to comprehend. But my feeling is that both 44(b) and 44(c) do follow from it, in accordance with Zeevat's prediction that the Fauconnier (or Heim) algorithm is appropriate in this case.[59]

6.3 Projection from Binary Connectives

Consider the following group of four five-way examples, some of which have already been discussed ((i–v) are understood according to the list beneath the examples):

(45) If David wrote the article then the knowledge that (i/ii/iii/iv/v) will confound the editors.

(46) If David wrote the article and the knowledge that (i/ii/iii/iv/v) disturbs the editors, they'll read the manuscript very carefully.

(47) If the knowledge that (i/ii/iii/iv/v) disturbs the editors and David wrote the article, they'll read the manuscript very carefully.

(48) Either David didn't write the article, or the knowledge that (i/ii/iii/iv/v) will confound the editors.

i = 'the article is already finished'

ii = 'he (i.e. David) wrote the article'

iii = 'he (i.e. David) wrote the article whilst blindfolded and juggling torches on horseback'

iv = 'no decent logician was involved (in writing the article)'

v = 'David is a computer program running on a PC'

[59] Cases like 44 constitute counterexamples not only to van der Sandt's theory, but to any theory where accommodation occurs at only one site. As discussed above, all the cancellation and filtering theories can be thought of as falling into this class. The problem will typically occur whenever a lexical presupposition is embedded under an operator which is itself embedded in an intensional context. For instance, 'Fred thinks Mary doesn't know that she won' involves the lexical presupposition trigger 'know' embedded under a negation operator itself embedded under 'thinks'. The example suggests not only that Mary won, which is predicted by cancellation theories, but also that Fred thinks she won, which is not predicted by these accounts.

Let us adopt a convention with respect to the proposition letters p, P, π, it being assumed that models are restricted such that $P \models \pi \models p$: all other proposition letters are assumed logically independent. So 45(i–iii) have the forms $P \rightarrow \phi_\pi$, $\pi \rightarrow \phi_\pi$ and $p \rightarrow \phi_\pi$, respectively.[60]

The theories which have been discussed in this chapter are broadly in agreement as regards 45(ii), $\pi \rightarrow \phi_\pi$, predicting (with the exception of Weak Kleene/Bochvar External) no non-trivial presupposition. The mechanisms behind the prediction vary, of course. For instance, the Karttunen '74 and Heim accounts rely on the antecedent setting up a context within which the presupposition of the consequent is satisfied, van der Sandt's DRT analysis is similar, albeit that logical satisfaction is replaced by anaphoric dependency. But Gazdar's account relies on an implicature triggered by the antecedent canceling the presupposition of the consequent.

If the antecedent of the conditional is stronger than the presupposition as in 45(i), then the Heim, Karttunen '74 and van der Sandt still predict no non-trivial presupposition, but Gazdar allows the presupposition to project. I take it that Gazdar's prediction is incorrect here, although it should be noted that the effects of prosody can make the judgement difficult.[61]

If the presupposition of the consequent is logically stronger than the antecedent as in 45(iii), Gazdar predicts cancellation, since the implicature that the antecedent is not known to be true conflicts with the presupposition. And this seems a justifiable result, for it is intuitively correct that the presupposition (iii) does not in fact project in this case.[62] Karttunen '74 and Heim do predict a substantive presupposition, $p \rightarrow \pi$, paraphraseable as: 'if David wrote the article then (iii)'.

It does seem that this conditional follows as a consequence of 45(iii). But here note that on the assumption that presuppositions are also asserted in their local context of evaluation, this will follow from classical reasoning: Gazdar's model predicts that $p \rightarrow \pi$ is entailed by $p \rightarrow \phi_\pi$, although not presupposed. This effect disappears with regard to the 46 variants. For 46(i-v) the presuppositional behavior of the Heim, Karttunen '74 and Gazdar models is just as for 45(i-v). In particular, with regard to 46(iii), $(p \wedge \phi_\pi) \rightarrow \psi$, Gazdar predicts cancellation, whereas Heim and Karttunen '74 predict the conditional $p \rightarrow \pi$. Crucially, this conditional does not follow as an entailment in Gazdar's model, so the contrast between the accounts is quite clear.[63] I take it that the conditional $p \rightarrow \pi$ does in fact follow from 46(iii), so we have an argument for preferring the Heim and Karttunen '74 models.

Here the reader should recall the earlier discussions of 45(iv,v) in §4.6 (there 30 and 31). These examples both have the form $\phi \rightarrow \psi_\pi$, the presupposition of the consequent not being *a priori* related to the antecedent. The Heim and Karttunen '74 theories predict a conditional presupposition $\phi \rightarrow \pi$ for both of these examples, as indeed they do for 46(iv,v). On the other hand, and in the absence of any special previous context, the cancellation models, Karttunen's '73 filtering model and van der Sandt's DRT model all predict projection of π. The conditionalised

[60] The contrast between CCP-style theories and cancellationist accounts wrt. sentences of form $P \rightarrow \phi_\pi$, $\pi \rightarrow \phi_\pi$ and $p \rightarrow \phi_\pi$ is discussed in the introduction to Heim's [Hei83a].

[61] If 45(i) is uttered with stress on 'David' (and possibly with destressing of 'the article is already finished') then we do appear to get projection of 'the article is already finished'. But then it could be argued that focussing in the antecedent was itself triggering the presupposition. See van der Sandt [vdS88] and Geurts [Geu95] for some arguments that in cases like this the presupposition may sometimes project, and my [Bea94b] for some further discussion of the relevance of prosody.

[62] Note that Karttunen's '73 theory incorrectly predicts full projection of the presupposition in this case, in the absence of a special context, although the theory correctly predicts no projection for 45(i) and 45(ii). The combined Gazdar/Karttunen theory discussed in the previous section would agree with Gazdar here, since it always predicts the weakest of the results given by either Gazdar or Karttunen '73.

[63] Whether or not Gazdar's model does predict cancellation for 46(iii) depends on the definition of the implicature function. This does yield cancellation for the subformula-based definition used above, but it is not clear to me whether Gazdar's original formulation predicts cancellation. Predicting simple projection would be no improvement empirically, since it is clear that 46(iii), just as 45(iii), does not presuppose that 'David wrote the article whilst blindfolded and juggling torches on horseback'. Note that van der Sandt's cancellation theory predicts cancellation for 46(iii). His later DRT account predicts local accommodation in this case, which leads to an equivalent reading. For 45(iii) van der Sandt's DRT account additionally allows the possibility of intermediate accommodation, giving a reading corresponding to 'If David wrote the article whilst blindfolded and juggling torches on horseback, then the knowledge that this was so will confound the editors'. Perhaps this reading is indeed possible, but it seems unintuitive that it is, as van der Sandt predicts, the preferred reading.

presupposition is intuitive for the (iv) variants, whilst simple projection seems appropriate for the (v)-s. It would seem that both classes of theories are in serious trouble. One solution might be obtained by strengthening the conditional presuppositions of the Heim and Karttunen '74 theories, perhaps along lines suggested by Karttunen and Peters in [KP79], or along those discussed above in §4.6. Another line of solution might involve somehow weakening the presupposition given by those theories which yield simple projection, although at present I am not aware of any concrete proposals that might achieve such weakening. What is clear is that a theory that is able to differentiate between the (iv) and (v) variants must incorporate reasoning that is of a non-absolute character, not simply about which propositions are true, or which propositions follow from which other propositions, but about which propositions are most *plausibly true* in a given utterance situation. Suggestions of Karttunen and Peters and the model discussed in §4.6 each provide possible beginnings for such an account, but there are undoubtedly many other ways that this might be achieved.[64]

There remain two sets of examples above to be discussed. Example 47 differs from 46 in that the order of an embedded conjunct is reversed, so that the difference is of interest because which reveals further differences between theories which make sentence internal conjunction symmetric (e.g. Strong Kleene, Supervaluation, Gazdar's cancellation theory) and those that do not (e.g. Karttunen's proposals including his joint work with Peters, Heim '83). The first class incorrectly make the same predictions for 47(i) as for 46(i), whereas the second class does not (but correctly predicts projection). I give 48 not to show differences between theories, but rather to show a common theme: theories tend to treat the 48 variants comparably to the equivalent versions of 45. But note that van der Sandt's DRT account is an exception. Whereas it predicts a case of anaphoric dependency without any accommodation in 45(i), it predicts projection of 'the article is already finished' for 48(i), because in standard DRT anaphoric dependencies cannot be established across disjunctions.[65]

The behaviour of various of the systems discussed in this chapter is summarised in the following table. The table concerns only quite simple instances of the projection problem. It does not include examples showing the way presuppositions project through quantifiers or modalities, or data demonstrating the anaphoricity of presuppositions. As a further simplification, a null context is assumed for theories which involve a contextual parameter, thus enabling a single *maximal presupposition* to be given for each theory and each example. The theories compared are Weak Kleene/External Bochvar (WK), Strong Kleene (SK), supervaluation semantics (SUP), Peters' connectives (P), Karttunen and Peters' two dimensional system[66] (KP), Karttunen's 1974 model (K74), Heim's 1983 model minus accommodation (H), Karttunen's 1973 model, Gazdar's cancellation theory (G), the combined Karttunen/Gazdar model introduced earlier (KG), and van der Sandt's DRT-based theory[67] (vdS).

[64]The move to bring common-sense reasoning and general world knowledge into the presuppositional arena has been advocated by other authors. For instance, Eco's discussion of presuppositions in [Ec94] centers around the idea that "the reader has to 'fill' the text with a number of textual inferences, connected to a large set of presuppositions defined by a given context..."; Hobbs and co-workers (see e.g. [HSAM90]) approach to definite descriptions (and to what are normally thought of as non-presuppositional constructions, for that matter) involves the introduction of a general inferential mechanism using weighted abduction, with the weights provided by a combination of world knowledge and knowledge of language; Thomason [Tho:MS] indicates that accommodation must take into account not only general world knowledge, but also reasoning about the communicative intentions of the speaker; Lorenz [Lor92] shows how world knowledge affects the behaviour of temporal presuppositions; and Kamp and Rossdeutscher [KRo94, Ros94] show in detail how inferencing mechanisms involved in processing presuppositional constructions must utilise a combination of lexical and world knowledge. Kay [Kay92] explains apparent projection from attitude contexts not as presupposition projection, but as conversational implicature.

[65]Krahmer [Krah:MS] proposes a development of van der Sandt's theory which would treat 45(i) and 48(i) identically, correctly predicting no global accommodation in either case.

[66]KP was not presented in terms of PrL, but its relation to other systems discussed is well established. As far as the connectives are concerned, Karttunen and Peters themselves demonstrated the link between their joint system and the trivalent Peters system discussed above.

[67]I use some latitude in interpreting how van der Sandt's model behaves, translating into natural DRT equivalents of the formulae given, and taking the maximal presupposition to be whatever is globally accommodated.

Formula	Maximal Presupposition								
	WK	SK/SUP	P/K&P/K74/H	K73	G	KG	vdS	Example	Data
ϕ_π	π	π	π	π	π	π	π	1	π
$\neg\phi_\pi$	π	π	π	π	π	π	π	3	π
$\phi \wedge \psi_\pi$	π	$\phi \rightarrow \pi$	$\phi \rightarrow \pi$	π	π	π	π		
$\phi_\pi \wedge \psi$	π	$\psi \rightarrow \pi$	π	π	π	π	π		
$\phi \vee \psi_\pi$	π	$\neg\phi \rightarrow \pi$	$\neg\phi \rightarrow \pi$	π	π	π	π		
$\phi_\pi \vee \psi$	π	$\neg\psi \rightarrow \pi$	π	π	π	π	π		
$\pi \rightarrow \phi_\pi$	π	$\top$	$\top$	$\top$	$\top$	$\top$	$\top$	45(ii)	$\top$
$(\pi \wedge \phi_\pi) \rightarrow \psi$	π	$\top$	$\top$	$\top$	$\top$	$\top$	$\top$	46(ii)	$\top$
$P \rightarrow \phi_\pi$	π	$\top$	$\top$	$\top$	π	$\top$	$\top$	45(iii)	$\top$
$(P \wedge \phi_\pi) \rightarrow \psi$	π	$\top$	$\top$	$\top$	π	$\top$	$\top$	46(iii)	$\top$
$p \rightarrow \phi_\pi$	π	$p \rightarrow \pi$	$p \rightarrow \pi$	π	$\top$	$\top$	$\top$	45(i)	$p \rightarrow \pi$ (?)
$(p \wedge \phi_\pi) \rightarrow \psi$	π	$(\neg\psi \wedge p) \rightarrow \pi$	$p \rightarrow \pi$	π	$\top$	$\top$	$\top$	46(i)	$p \rightarrow \pi$ (?)
$(\phi_\pi \wedge P) \rightarrow \psi$	π	$(\neg\psi \wedge p) \rightarrow \pi$	π	π	$\top$	$\top$	$\top$	47(iii)	π
$\neg\phi_\pi \wedge \neg\pi$	$\bot$	$\bot$	$\bot$	π	$\top$	$\top$	$\top$	12	$\top$
$\sharp\phi_\pi \wedge \neg\pi$	$\top$	$\top$	$\top$	$\top$					
$\neg(K\phi)_\pi$				π	$\top$	$\top$	$\top$	14	$\top$
$\phi_\pi \vee \phi_{\neg\pi}$	$\bot$	$\bot$ (SK)	$\bot$	$\bot$	$\top$	$\top$	$\top$	11	$\top$

Projection from the so-called *logical* connectives, although the most oft studied part of the projection problem, remains an area rife with disagreement. The examples above show only a part of the problem. Symmetry of connectives with respect to presuppositional behaviour, for instance, is an issue not only with respect to conjunctions, but also with respect to conditionals and disjunctions.[68] Regarding disjunction, one should consider reversing the order of the disjuncts in the 48 examples above. The reversed 48(ii) seems to be acceptable, if perhaps stilted. Just as for the 'forwards' version, the presupposition is apparently not projected, so we have an argument for symmetry. But consider the reversal of 48(i) 'Either the knowledge that the article is already finished will disturb the editors, or David didn't write the article.' My intuition is that a projection reading is preferred for this example, unlike for 48(i) itself. If this is so, it provides an argument against symmetry.

The data is clearly complex, and more empirical work is needed. Aside from systematic further study of examples like those considered above, I would like to close this article somewhat polemically by mentioning three respects in which future emprical work might substantially improve upon most existing research. Firstly, many of the examples given here, and elsewhere in the literature, rely crucially on intonation, and there is a clear need for future work to cite examples with prosodic marking.[69] A second, related area is provision of examples with explicit textual or discourse context. Note that many theorists emphasize the importance of discourse context, yet few give examples much longer than one or two sentences.[70] A third area where future research might benefit is in the use of naturally occurring examples. The use of artificial examples, as in

[68] Detailed empirical arguments concerning symmetry of connectives are presented by Soames [So79, So82, So89].

[69] I give just one example of the importance of prosody. Soames [So82] has discussed examples (A) 'If Nixon is guilty, too, then Haldeman is guilty.' and (B) 'Haldeman is guilty, if Nixon is guilty too.'. He claims that whereas (B) can be read without requiring that anyone is established to be guilty, i.e. such that the presupposition in the antecedent is satisfied by material in the consequent, this is not the case for (B). On the other hand Kay [Kay92, p.359,fn.32] mentions that if (A) is intoned with stress on 'too' and no preceding pause, the same reading is available as for (B). Neither Kay nor anyone else has explained the role of intonation here. Likewise, the reason why ordering of the sub-clause and main clause should be important is unexplained. (As a complete aside, note that 'Haldeman might be guilty, if Nixon is guilty too.', with appropriate intonation, appears to be at least as felicitous as (A). The extra embedding under a modal operator adds yet another layer of mystery, since according to conventional wisdom the modal should block anaphoric accessibility of 'Haldeman is guilty' independently of the use of a conditional.)

[70] What role does textual context play in examples like those in footnote 69, above? What after all do (A) and (B) mean? If they mean the same as it would without the 'too', then in what contexts is the 'too' appropriate? To take a different example of the relevance of discourse context, consider Landman's discussion [La86] of disjunctions with competing presuppositions in the disjuncts, c.f. 11, above. He claims the observed projection effects are not tied to properties of disjunctions as such, but result from a special sort of discourse subordination.

this article, remains the predominant method amongst presupposition theorists. Yet some theorists have shown that this is not the only possible methodology. See especially Delin's use of corpora to investigate clefts [Deli90, Deli92], or, e.g. Prince's use of textual examples and taped discourse in [Pri81]. Presupposition is an ideal area for the use of corpora. Given that we have an independent method (projection tests) of identifying (likely) triggers, it should in principle be easy to trawl through a corpus using the triggers as search keys. And if, say, the interaction between presupposition and attitude reports is to be studied, then a more refined search for triggers occurring in the propositional argument of an attitude predicate would be feasible over a syntactically pre-analysed corpus. Such work is necessary, but whether it would 'solve' existing empirical questions is another matter. Naturally occurring data is perhaps more likely to throw up new empirical phenomena rather than clarifying existing areas of concern.

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