Symmetric and Interacting Alternatives for Implicature and Accommodation*

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This paper uses the proviso problem to argue that accommodation is computed by the system responsible for scalar implicature. Standard procedures for computing implicatures involve: (i) Generating a candidate set of potential implicatures based on formal principles, (ii) Employing an algorithm over this set of candidates to determine which become actual. I argue that a very similar computation takes place in accommodation: A candidate set of accommodations is generated, from which an algorithm selects a subset as the actual accommodations. The parallel runs extremely close. The candidate sets for both implicature and accommodation will be argued to derive from a single source, namely, the scalar alternatives of the asserted sentence. Moreover, the algorithm for converting potential enrichments into actual enrichments will be argued to be the same. Specifically, the algorithm will take the union of the two sets as input, and will compute implicatures and accommodations together. This move will allow potential implicatures and potential accommodations to cancel each other out, in a sense to be made precise. This will be argued to be the key to solving the proviso problem, in addition to some problems that I'll identify in the theory of implicature. The general architecture has obvious roots in the work of Gazdar [12], Soames [45], and Heim [22]. Some of the specific technology employed depends on recent developments in the theory of implicature, specifically, Katzir's [27] procedure for generating scalar alternatives, and Fox's [8] algorithm for converting potential implicatures into actual ones.

1 The Proviso Problem

Where sentence ψ presupposes proposition p, ψ_p, several theories of presupposition projection predict conditional sentences 'if ϕ, then ψ_p' should presuppose $\phi \to p$.[1] For example, the following sentence is predicted to presuppose that if John flies to Toronto, he has a sister.

1. If John flies to Toronto, his sister will pick him up from the airport.

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[1]Eg. Karttunen [24, 25], Stalnaker [48], Karttunen and Peters [26], Peters [32], Heim [18], Beaver [1], Beaver and Krahmer [3], Schlenker [37, 39, 38], Chemla [5], Fox [9, 10], George [13].

It has often been pointed out (eg. Gazdar [12], Geurts [14]) that this prediction seems too weak. The sentence seems to presuppose instead that John has a sister, whether or not he flies to Toronto. The various responses to this mismatch have appealed to the the notion of conversational reasoning to overcome the apparent puzzle.[2] It is well known (eg. from the theory of scalar implicature) that there are processes that sometimes enrich the propositions computed by grammar, so while (1) may well presuppose that John has a sister on the condition that he flies to Toronto, it is not inconceivable to imagine there being an enrichment process that can kick in to strengthen this proposition to John having a sister whether or not he flies to Toronto.

A more serious objection faced by this line of reasoning, due to Geurts [14], comes from sentences like (2). Although this sentence also presupposes (as a matter of projection) that if John flies to Toronto he a sister, we do not infer upon hearing (2) that John does indeed have a sister:

2. Mary knows that if John flies to Toronto, he has a sister

I will assume, following the standard response, that this so-called proviso problem is a problem for the theory of accommodation:

The Proviso Problem Why, when we hear two sentences that project the same presupposition, do we accommodate such different kinds of information in response to them?

Several proposals for dealing with the contrast in (1) and (2) exist (eg. Beaver [2], Heim [22], van Rooij [33], Singh [42], Pérez Carballo [30, 31]). While Singh [42] uses the above contrast to argue for the existence of a separate accommodation module, the others hold certain facts about conversational reasoning as being responsible for the contrast. Very roughly, Beaver [2] specifies assertability conditions on conditionals that he argues capture the contrast, while Heim [22], van Rooij [33], and Pérez Carballo [30, 31] argue that implicatures, along with various additional assumptions about the interpretation of conditionals in addition to certain default assumptions about the context, apply in specific ways to block accommodation of John having a sister in (2) without blocking this inference in (1). Both lines of attack seem to me to face certain problems of generality. My own earlier proposal rested on the notational conventions of the dynamic semantic framework of Heim [18]. As such, in addition to inheriting difficulties of explanatory adequacy that have been raised for that approach (eg. Soames [46], Heim [19]), the proposal was not readily extendible to other theories of projection. The conversational reasoning approach, while providing a basis for the contrast between (1) and (2), rests on assumptions that are tied to the case of conditionals and conditional presuppositions, and thus falls short of providing a predictive statement of what one normally expects to get accommodated in response to any given sentence.[3]

These difficulties become apparent once we try to account for instances of the proviso problem that lie outside the realm of conditional presuppositions. For example, one well-known case of

[2] Eg. Karttunen and Peters [26], Beaver [1, 2], Beaver and Zeevat [4], von Fintel [7], Heim [22], Pérez Carballo [30, 31], van Rooij [33], Singh [42, 43].

[3] Space considerations prevent a detailed discussion here. Very roughly, van Rooij [33] invokes default assumptions about 'independence' between the antecedent and consequent to determine when a conditional presupposition can be strengthened. Pérez Carballo [31] invokes a notion of when a context 'collapses' a conditional presupposition to an unconditional one. Heim [22] stipulates a candidate set of accommodations in response to conditional sentences like (1). It is not clear (to me) how to extend these ideas to other cases, eg. the belief attributions below. See Singh [43] for more discussion.

the proviso problem occurs in belief attributions (eg. Karttunen [24], Heim [21]). Although the following sentence is predicted to project that John believes it was raining (eg. Karttunen [24], Heim [21], Schlenker [38]),[4] what we accommodate in response is not only that John believes it was raining, but also that it was in fact raining:

3. John believes it stopped raining

And again, Geurts [15] provides evidence that different constructions presupposing that John believes it was raining do not inevitably lead to the accommodation that it was in fact raining:

4. Mary knows that John believes it was raining

What we should like, then, is a general, predictive theory of presupposition accommodation that can deliver the above results, extending to any arbitrary sentence. The goal of this paper is to develop such a theory.[5] In pursuing this goal, I will follow the intuition expressed by the conversational reasoning response to the proviso problem, namely, that the accommodation system has to be responsible to various other kinds of inferences that can be drawn from the asserted sentence. More specifically, I will begin by following certain aspects of the proposal in Heim [22]. The proviso problem teaches us, minimally, that accommodation cannot be trivial: If accommodation is required in response to ϕ_p in context c, accommodation of some $q \neq p$ can often take place, so long as $c \cap q$ is a subset of $c \cap p$.[6] To account for this non-triviality, we follow Heim [22] in assuming there to be a candidate set of potential accommodations available, $\mathcal{H}$. We also follow Heim in adopting the following constraint on accommodation, which dictates, essentially, that scalar implicatures/ignorance inferences can *cancel* potential accommodations:[7]

Cancellation of Potential Accommodations Suppose ϕ is the assertion, and let $\mathcal{H}$ be the candidate set of potential accommodations in response to ϕ. If accommodation of $p \in \mathcal{H}$ would contradict a scalar implicature/ignorance inference generated by ϕ, then accommodation of p is not allowed.

To turn this into a predictive statement, we need, first, to eliminate the case by case stipulations concerning the makeup of $\mathcal{H}$ that are currently required (cf. Note 3). Second, given an algorithm for constructing $\mathcal{H}$, we need to state a procedure for determining which potential accommodations become actual. We will develop the desired statements in Sections 2 and 3. But before doing so, since the interaction with implicatures is crucial to the account, and since intuitions concerning the implicatures of the sentences we're dealing with are not entirely straightforward to intuit, let me try to provide some reasons for thinking that something like Heim's cancellation principle is on the right track for dealing with the proviso problem.

Several theories of implicature (eg. Gazdar [12], Sauerland [36], Fox [8]) predict that the constituents in a disjunction and a conditional give rise to (speaker) ignorance inferences (instead of

[4]Where $B_j\phi$ symbolizes 'John believes that ϕ,' $B_j\phi_p$ presupposes that B_jp.

[5]See Zeevat [49], Geurts [15] for proposals couched within a DRT framework.

[6]Though see Pérez Carballo [31] for a dissenting opinion.

[7]This of course recalls Gazdar's [12] cancellation mechanism, under which implicatures cancel potential presuppositions.

scalar implicatures). For example, assertion of $X \vee Y$ will normally generate the scalar implicature that $\neg(X \wedge Y)$, and the ignorance inferences $\Diamond_S X$ (the speaker considers it possible that X), $\Diamond_S \neg X$, $\Diamond_S Y$, $\Diamond_S \neg Y$. Similarly, conditionals 'if X, then Y' give rise to these same ignorance inferences as well (we will see why later in the paper). Now consider the oddness of the following sentences:

5. (a) # I have two or more sons (cf. John has two or more sons, I have more than one son)
   (b) # If I'm married to an American, I have two sons (cf. If John is married to an American, he has two sons)

A plausible account of the oddness of (5a) and (5b) is that the ignorance inferences that they give rise to contradict common knowledge (eg. the common knowledge that people normally know how many sons they have), and that this contradiction is the source of the oddness.[8] For our purposes, we can use this oddness as a detector of strange ignorance inferences. Now, with respect to providing some initial support for the cancellation principle above, what is important to note is that an oddness similar to that generated in (5a,b) is found when we embed these structures under *know*, even in DE contexts (which are normally thought to shut off implicature-like reasoning):

6. (a) # No one knows I have two or more sons (cf. No one knows John has two or more sons)
   (b) # No one knows that if I'm married to an American, I have two sons (cf. No one knows that if John is married to an American, he has two sons)

This oddness suggests that, in (6b) for example, the constitutent 'I have two sons' is subject to a speaker ignorance inference. Together with the cancellation principle, this would suffice to block accommodation of the speaker's having two sons. Note that for this to be so, the notion of consistency relevant for application of Heim's cancellation principle would have to be restricted to contextual information. There is no logical contradiction between the speaker being ignorant about whether they have two sons, and the proposition that they do have two sons. It is only when we attempt to accommodate the latter, i.e. add the proposition to the common ground, that a contradiction with speaker ignorance would be detected.[9]

Let me turn now to the first of our tasks, that of trying to provide an intensional characterization of the candidate set of potential accommodations.

2 Deriving Candidate Sets of Potential Accommodations

As noted above, sentences like (1) and (3) teach us that accommodation cannot be trivial. I have argued elsewhere (eg. Singh [42, 43]) for the need to restrict the set of accommodation possibilities to those derivable from formal properties of the asserted sentence alone. Such a restriction is known to exist elsewhere in systems that enrich meaning. For example, in deriving a candidate set of potential implicatures in response to assertion ϕ, it has been commonly assumed since Horn [23] that this candidate set of propositions is generated through the use of formally restricted alternative logical forms, the so-called scalar alternatives of ϕ, $A(\phi)$. It would be fairly natural to think

[8] This would be an extension of the idea that oddness results when scalar implicatures contradict common knowledge (eg. Hawkins [17], Heim [20], Fox and Hackl [11], Magri [29]).

[9] 'It is common knowledge that ϕ' entails 'the speaker knows that ϕ.'

that the accommodation system exploits this resource for generating candidate sets of potential accommodations, i.e. that the scalar alternatives are the only route to candidate enrichments. I propose that this is indeed the case:

Candidate Set of Potential Accommodations For assertion ϕ, the set of potential accommodations is $\mathcal{H} = \{\pi(\psi) : \psi \in A(\phi)\}$, where $\pi(\psi)$ is the projected presupposition of sentence ψ.

The procedure for generating candidates for accommodation takes the set of scalar alternatives (a set of LFs derived from the asserted LF) and computes their projected presuppositions (a set of propositions). For the purposes of this note, I will assume Katzir's [27] procedure for generating scalar alternatives. Very roughly, this procedure generates various subtrees as alternatives, as well as trees generated by replacing certain lexical items in the tree with related items from a substitution source, usually the lexicon, but also other subtrees of the given parse.[10]

Returning to the basic paradigm of the proviso problem in (1)-(4) (repeated here as (7)-(10)), let us write out the candidate set of potential accommodations in each case.[11]

7. If John flies to Toronto, his sister will pick him up from the airport = 'if ϕ, then ψ_p'
Scalar Alternatives: $A(7) = \{\text{if } \phi \text{ then } \psi_p, \phi, \neg\phi, \psi_p, \neg\psi_p\}$[12]
Candidates for Accommodation $\mathcal{H} = \{\pi(\psi) : \psi \in A(7)\} = \{\phi \rightarrow p, p\}$[13]

The procedure generates two candidates for accommodation: (i) that if John flies to Toronto, he has a sister, and (ii) that John has a sister. The second is the required enriched candidate. Unfortunately, this candidate is also generated when (i) is projected out of a factive complement:

8. Mary knows that if John flies to Toronto, he has a sister = K_m(if ϕ, then ψ)
Scalar Alternatives: $A(8) = \{K_m$(if ϕ, then ψ), $K_m\phi$, $K_m\neg\phi$, $K_m\psi$, $K_m\neg\psi$, if ϕ then ψ, ϕ, $\neg\phi$, ψ, $\neg\psi\}$.
Candidates for Accommodation: $\mathcal{H} = \{\phi \rightarrow \psi, \phi, \neg\phi, \psi, \neg\psi\}$.

It will have to be up to the decision procedure that selects among the potential candidates, then, to ensure that ψ (that John has a sister) is not an allowable accommodation in this case. As noted above, we're going to follow Heim [22] in appealing to the theory of implicature to help us get this result. We'll get to that in the next section. For now, let's write out the set of candidate accommodations in the belief attributions.

[10] See the appendix for a complete statement.

[11] To reduce clutter, my notation will generally not distinguish between sentences and propositions. Throughout, I ask the reader to keep in mind that scalar alternatives are always logical forms, and potential enrichments (like potential implicatures and potential accommodations) are propositions (so that conjunction, disjunction, negation amount to intersection, union, set complement, respectively).

[12] $\neg\psi_p$ is generated by replacing 'if ϕ' in 'if ϕ, then ψ_p' by $\neg$, as both are one-place functions from truth-values to truth-values that compose in such a way as to take ψ_p as an argument. Since Katzir's proposal allows one to substitute subtrees for other subtrees in the current parse, swapping ϕ and ψ_p, we can also get $\neg\phi$.

[13] $\pi(\text{ if } \phi \text{ then } \psi_p) = \phi \rightarrow p$, $\pi(\psi_p) = \pi(\neg\psi_p) = p$, and ϕ is presuppositionless.

9. John believes it stopped raining
Scalar Alternatives $A(9) = \{B_j(S_r), S_r, K_j(S_r)\}$.[14]
Candidates for Accommodation $\mathcal{H} = \{B_j r, r, S_r \wedge K_j r\}$.[15]

Recall that in this case, we want to accommodate two propositions: that John believes it was raining, and that it was in fact raining. These are indeed two of the three candidates we generate ($B_j r$, r). The decision procedure that selects what to accommodate will thus have to be able to select multiple propositions from $\mathcal{H}$. However, it will have to avoid selecting the entire set, since we don't want to predict that $S_r \wedge K_j r$ (that it stopped raining and John knows it was raining) is accommodated in respone to (9).

And, finally, when we embed $B_j r$ under *know*, we get r (that it was raining) as an accommodation alternative, which will have to be blocked:

10. Mary knows that John believes it was raining
Scalar Alternatives: $A(10) = \{K_m B_j r, K_m r, B_j r, r, K_m K_j r, K_j r, B_m B_j r, B_m r, B_m K_j r\}$
Candidates for Accommodation $\mathcal{H} = \{r, K_j r, B_m r, B_j r\}$

We have in place now a way to generate candidates for accommodation. In the next section, by putting in place certain assumptions about implicature computation, we'll be able to provide a fully general statement of the interaction of accommodation candidates and Heim's cancellation principle. This will allow us to state, for each $\mathcal{H}$, which candidate accommodations are prevented from becoming actual. We'll see, however, that we might be more ambitious still, adapting algorithms proposed for implicature computation for the purpose of also saying which potential accommodations *will* become actual.

3 Interactions with Implicature

Scalar implicatures arise through a process of enrichment. Given a sentence ϕ, implicatures are computed by: (i) Generating a candidate set of potential implicatures, $\mathcal{N}$,[16] (ii) Employing a decision procedure over $\mathcal{N}$ to determine which subset of $\mathcal{N}$ becomes the set of actual implicatures.[17] As stated earlier, I will follow the basic approach to generating $\mathcal{N}$ taken by Katzir [27]. I will also follow here, without comment, the algorithm for selecting among candidate implicatures developed by Sauerland [36], and more directly Fox [8].[18]

We can get at the key insight behind this algorithm by considering the case of disjunctions, $X \vee Y$. We first need to say, what is the candidate set of potential implicatures, $\mathcal{N}$? These are derived from the scalar alternatives of the sentence, $A(X \vee Y)$. Following Katzir [27], this will yield the set of LFs $A(X \vee Y) = \{X \vee Y, X, Y, X \wedge Y\}$. From this set, we get the candidate set of potential implicatures by negating the propositions denoted by the members of $A(X \vee Y)$:

[14] Legend: r = it was raining, S_r = it stopped raining, $B_j\phi/K_j\phi$ = John believes/knows that ϕ.
[15] $\pi(B_j(S_r)) = B_j r, \pi(S_r) = r, \pi(K_j(S_r)) = S_r \wedge K_j r$ (Karttunen [24], Heim [21]).
[16] See (eg.) Horn [23], Gazdar [12], Sauerland [36], Katzir [27] for proposals regarding the generation procedure.
[17] In addition to the above references, see (eg.) Chierchia [6], van Rooij and Schulz [34], Russell [35], Schulz and van Rooij [40], Spector [47], Fox and Hackl [11], Fox [8], Klinedinst [28], Magri [29], Chemla [5], Sharvit and Gajewski [41], and much other recent work.
[18] In Singh [44] I present arguments for preferring this approach over competing proposals (eg. Gazdar's [12]).

Candidate Set of Potential Implicatures For assertion ϕ, the set of potential implicatures is $\mathcal{N}$ = $\{\neg[[\psi]] : \psi \in A(\phi)\}$.

For disjunctions $X \vee Y$, then, we have: $\mathcal{N} = \{\neg(X \vee Y), \neg X, \neg Y, \neg(X \wedge Y)\}$. Given this set of potential implicatures, the fact that needs to be accounted for is that only $\neg(X \wedge Y)$ ends up as an actual implicature, while we get ignorance inferences about $\neg X, \neg Y$.

Fox's [8] procedure, building on insights from Groenendijk and Stokhof [16] and Sauerland [36], attempts to convert as many potential implicatures into actual implicatures as possible while maintaining consistency with the asserted proposition. Suppose the procedure is given $\mathcal{N}$ above as input. It now goes about trying to negate as many potential implicatures as it can. Note that if the procedure includes $\neg X$ as an actual implicature, it cannot (on pain of inconsistency) also draw $\neg Y$ as an actual implicature. Thus, the best it can do, given $\neg X$, is the following set: (i) $\{\neg X, \neg(X \wedge Y)\}$. Call such a set a *Maximal Consistent Inclusion*, MCI, a subset of $\mathcal{N}$ that can accept no further members of $\mathcal{N}$ without running into inconsistency. Given this set, we are good to ask: Why is it that $X \vee Y$ never ends up meaning 'Y and not X?' The fact that $\neg X$ never shows up as an actual implicature of $X \vee Y$ teaches us that the MCI in (i) cannot be the set of actual implicatures. The reason Fox offers for this is that there is another MCI of $\mathcal{N}$, namely (ii) $\{\neg Y, \neg(X \wedge Y)\}$. There are no other MCIs of this set, and it would seem arbitrary to pick one MCI over the other as the optimal choice for the set of actual implicatures, so what can be done? Fox suggests that the only non-arbitrary set of propositions to include as actual implicatures would seem to be those that are in every MCI of $\mathcal{N}$, what we'll call (modifying Fox's terminology, but changing nothing of substance) the 'innocently includable propositions.' The actual implicatures of a sentence are all and only those potential implicatures that are innocently includable. All other potential implicatures whose truth-value is not determined by the above algorithm are subject to speaker ignorance inferences.

With this setup in place, we are now in position to apply Heim's cancellation principle to any arbitrary sentence ϕ. For any such sentence, we can compute two sets of candidate enrichments, $\mathcal{N}$ and $\mathcal{H}$, both derived from a single set of objects, the scalar alternatives of ϕ, $A(\phi)$. By executing innocent inclusion over $\mathcal{N}$, we'll have a set of scalar implicatures/ignorance inferences that can be used to prevent certain members of $\mathcal{H}$ from becoming actual accommodations. We will see momentarily how far we can get with this framework in place. However, before working through some cases, I'd like to raise an alternative way of dealing with the proviso problem that invokes no interaction at all between the implicature system and the accommodation system, one that is made possible by the innocent inclusion algorithm responsible for implicature computation. In addition to allowing accommodation and implicature to remain separate (for what that's worth), it also provides a positive statement for predicting which members of $\mathcal{H}$ will become actual.

Consider again for example the candidate set of potential accommodations for (8) (= *Mary knows that if John flies to Toronto, he has a sister* = K_m(*if* ϕ, *then* ψ)) = $\mathcal{H}$ = $\{\phi \rightarrow \psi, \phi, \neg\phi, \psi, \neg\psi\}$. We want to know: Why is $\phi \rightarrow \psi$ the only allowed accommodation from $\mathcal{H}$? Why don't we ever see ψ as an accommodation in response to (8)? The question seems analogous to the question of why in a disjunction, $X \vee Y$, only one member of the set of potential implicatures $\{\neg(X \vee Y), \neg X, \neg Y, \neg(X \wedge Y)\}$ becomes actual $(\neg(X \wedge Y)\}$. The others do not because they are not innocently includable. So suppose, for a moment, that innocent inclusion also operates over $\mathcal{H}$, where it tries to find maximal consistent subsets of $\mathcal{H}$, subject to the constraint that the projected presupposition belong to each maximal consistent subset (in order to ensure presupposition satisfaction). The intersection of such maximal consistent subsets, or maximal consistent inclusions (MCIs), would be the innocently includable propositions from $\mathcal{H}$. As with implicatures, we might conclude that $p \in \mathcal{H}$ is an actual accommodation iff it is innocently includable. A quick computation will reveal that the only member of $\mathcal{H}$ above that is innocently includable is the projected presupposition itself, $\phi \rightarrow \psi$, as desired.[19]

We thus have two proposals currently on the table. The first has it that there is *interaction* of a particular kind between $\mathcal{N}$ and $\mathcal{H}$, namely, through the cancellation principle of Heim [22]. One can imagine this being coupled with various ways of selecting members of $\mathcal{H}$ as actual accommodations. The second, discussed above, posits no interaction between $\mathcal{N}$ and $\mathcal{H}$ at all. Instead, it has innocent inclusion operate in parallel computations over $\mathcal{N}$ and $\mathcal{H}$, with no communication between the two processes. We'll examine these options in the next section. We'll see that, limiting ourselves to conditional presuppositions, we won't be able to decide between the two. The crucial evidence will come from belief attributions.

Before turning to the examples, let me introduce some terminology here that (I hope) will make it easier to follow the discussion in the next section. Let us call two potential enrichments *symmetric alternatives* if they can't both belong to an MCI together. For example, in the case of disjunctions $X \vee Y$, the potential implicatures $\neg X$, $\neg Y$ are symmetric alternatives, since they prevent each other from belonging to an MCI together. It follows from this definition that symmetric alternatives are never innocently includable. While this notion (of 'symmetric alternatives') is not strictly part of the theory, I introduce it here with the hope that it makes it easier to follow the examples without having to work through complex computations. Strictly speaking, however, the only way to determine which potential enrichments become actual is to determine the MCIs and take their intersection.[20]

3.1 Choice Points in the Interaction between $\mathcal{N}$ and $\mathcal{H}$

Let's begin with (7), repeated here as (11):

11. If John flies to Toronto, his sister will pick him up from the airport = 'if ϕ, then ψ_p'
Scalar Alternatives: $A(11) = \{\text{if } \phi \text{ then } \psi_p, \phi, \neg\phi, \psi_p, \neg\psi_p\}$
Candidates for Implicature $\mathcal{N} = \{\neg(\phi \rightarrow \psi_p), \phi, \neg\phi, \psi_p, \neg\psi_p\}$
Candidates for Accommodation $\mathcal{H} = \{\pi(\psi) : \psi \in A(11)\} = \{\phi \rightarrow p, p\}$

How would the cancellation principle work? We first compute our scalar implicatures/ignorance inferences. It is easy to see that, in $\mathcal{N}$, ϕ and $\neg\phi$ are symmetric (they can't both be in an MCI together, due to consistency requirements), and ψ_p and $\neg\psi_p$ will also cancel each other out. By working through the innocent inclusion algorithm with $\mathcal{N}$ as input, it turns out that no member of $\mathcal{N}$ is innocently includable.[21] All that is predicted, then, are (speaker) ignorance inferences about the antecedent and consequent of the conditional. These ignorance inferences are entirely

[19]The MCIs are: (i) $\{\phi \rightarrow \psi, \phi, \psi\}$, (ii) $\{\phi \rightarrow \psi, \neg\phi, \psi\}$, (iii) $\{\phi \rightarrow \psi, \neg\phi, \neg\psi\}$.

[20]There are non-innocently includable propositions that do not come in pairs of symmetric alternatives in this sense. For example, consider the question *Who came to the party?*, with the answer *Some boy*. Here, all answers of the form 'x came to the party,' where x is a boy in the domain of quantification, will turn out to not be innocently includable, although they are not symmetric in this strong sense.

[21]The MCIs are: (i) $\{\phi, \psi_p\}$, (ii) $\{\neg\phi, \psi_p\}$, (iii) $\{\neg\phi, \neg\psi_p\}$.

consistent with accommodation of either member of $\mathcal{H}$, so the cancellation principle, while not predicting which member(s) of $\mathcal{H}$ will be accommodated, allows for either one. Importantly, the principle does not block accommodation of p, that John has a sister.

The alternative account, where innocent inclusion operates over $\mathcal{H}$ in a way that is 'blind' to what happens in $\mathcal{N}$, would compute a unique MCI, namely, $\mathcal{H}$ itself. This is because the members of $\mathcal{H}$ are consistent with one another. Indeed, one member entails the other. Thus, the predicted accommodation here is $p \wedge (\phi \rightarrow p) \equiv p$, i.e. that John has a sister. Thus, this case at least does not seem to decide between the two current proposals. It turns out that Geurts' case of embedding under *know* doesn't either. Let's see why. We repeat the example as (12) here:

12. Mary knows that if John flies to Toronto, he has a sister = K_m(if ϕ, then ψ)
    Scalar Alternatives: $A(12) = \{K_m$(if ϕ, then ψ), $K_m\phi$, $K_m\neg\phi$, $K_m\psi$, $K_m\neg\psi$, if ϕ then ψ, ϕ, $\neg\phi$, ψ, $\neg\psi\}$.
    Candidates for Implicature: $\mathcal{N} = \{\neg K_\alpha(\phi \rightarrow \psi)$, $\neg K_\alpha\phi$, $\neg K_\alpha\neg\phi$, $\neg K_\alpha\psi$, $\neg K_\alpha\neg\psi$, $\neg(\phi \rightarrow \psi)$, ϕ, $\neg\phi$, ψ, $\neg\psi\}$.
    Candidates for Accommodation: $\mathcal{H} = \{\phi \rightarrow \psi, \phi, \neg\phi, \psi, \neg\psi\}$.

Let's begin by applying innocent inclusion to the set $\mathcal{H}$. It is easy to see that we will face problems of symmetry: $\phi, \neg\phi$ will be symmetric, as will $\psi, \neg\psi$. As noted earlier, the only member of $\mathcal{H}$ not beset by a symmetry problem is the projected presupposition itself, $\phi \rightarrow \psi$ (that if John flies to Toronto, he has a sister). This is predicted to be the only allowed accommodation, which is the desired result.

On the other hand, working through $\mathcal{N}$, we can again pick off some instances of symmetric alternatives. The constituents of the embedded conditional will all face problems of symmetry: $\phi, \neg\phi$ and $\psi, \neg\psi$ come in symmetric pairs. These will thus be subject to speaker ignorance inferences. Working through the innocent inclusion algorithm, we see that the only innocently includable propositions in $\mathcal{N}$ are the members of the set $\{\neg K_\alpha\phi$, $\neg K_\alpha\neg\phi$, $\neg K_\alpha\psi$, $\neg K_\alpha\neg\psi\}$. This means that, in addition to these (in effect) ignorance inferences about the subject of the knowledge attribution (Mary, in this case), the antecedent and consequent of the conditional embedded under *know* also undergo *speaker* ignorance inferences.[22] These speaker ignorance inferences in turn will prevent accommodation of all members of $\mathcal{H}$ except the projected presupposition, $\phi \rightarrow \psi$ (because of Heim's cancellation principle).

Thus, at least as far as the case of conditional presuppositions is concerned, we don't have any evidence about the nature of the interaction (if any) between $\mathcal{N}$ and $\mathcal{H}$. I think some fairly decisive evidence comes from (9), which we repeat here as (13):

13. John believes it stopped raining
    Scalar Alternatives $A(13) = \{B_j(S_r), S_r, K_j(S_r)\}$.
    Candidates for Implicature $\mathcal{N} = \{\neg B_j S_r, \neg K_j S_r, \neg S_r\}$
    Candidates for Accommodation $\mathcal{H} = \{B_j r, r, S_r \wedge K_j r\}$.

Consider the set $\mathcal{H}$. The desired accommodation from this set is the set of propositions $\{B_j r, r\}$ (i.e that John believes it was raining, and that it was in fact raining). The candidate that needs to be blocked is $S_r \wedge K_j r$, i.e. that it stopped raining and John knows it was raining (we do not take

[22]Hence accounting for the observation made in (6) at the end of Section 1.

away from this sentence that it did, in fact, stop raining). It turns out that neither of our current proposals captures this fact.

To see this, first, note that when we run innocent inclusion over $\mathcal{H}$, the entire set is innocently includable. Without any intervention from $\mathcal{N}$, there seems to be no obvious way to block the unwanted accommodation.

So let us turn to $\mathcal{N}$ for help. It turns out that there is a member of $\mathcal{N}$ that could, in principle, serve to block this inference, namely $\neg S_r \in \mathcal{N}$. Unfortunately, this proposition is not a real implicature of the sentence, i.e. we are not licensed to infer from *John believes it stopped raining* that it didn't stop raining. Thus, the cancellation principle, as it stands, is not of any help here, either.

A clue as to how to overcome this difficulty comes from the fact that $\neg S_r$ is the only unwanted potential implicature from $\mathcal{N}$. In other words, we need a way to block $\neg S_r$ from becoming an actual implicature. However, as it stands, the innocent inclusion algorithm actually predicts this to become an actual implicature.[23] Thus, we have two candidate enrichments, one from $\mathcal{N}$, and one from $\mathcal{H}$, which we need to block, but have no means currently available to do so. However, if the two potential enrichments could somehow cancel each other out before either became actual, the difficulty could be overcome. In other words, (13) seems to be teaching us that we need to allow potential implicatures and potential accommodations to prevent one another from becoming actual:

Bidirectional Cancellation Potential implicatures and potential accommodations can cancel each other out.

Of course, as we saw with the case of disjunctions, potential enrichments cancelling each other out is the hallmark of symmetry among potential enrichments. I thus propose to make sense of the need for bidirectional cancellation among potential implicatures and accommodations by modifying innocent inclusion so that it takes as input not merely $\mathcal{N}$, but rather $\mathcal{N} \cup \mathcal{H}$. This move allows candidates from $\mathcal{N}$ and $\mathcal{H}$ to not only create symmetry problems for each other, but also for members of the other set. Symmetry between members of $\mathcal{N}$ (eg. $\neg S_r$) and $\mathcal{H}$ (eg. $S_r \wedge K_j r$) is crucial for cases like (13). At the same time, symmetry within $\mathcal{N}$ and $\mathcal{H}$ with no interaction between the two suffices to capture the cases of conditional presuppositions, in addition to the ignorance inferences needed for cases like (6). Of course, expanding the set of potential enrichments (to $\mathcal{N} \cup \mathcal{H}$) can never reduce the amount of symmetry within a set, so the enlarged input will be innocuous for such cases.

I work through our examples below using the revised version of innocent inclusion (which takes $\mathcal{N} \cup \mathcal{H}$ as input). I give a complete statement of the procedure in the appendix. Here, suffice it to note that the constraints on the MCIs of $\mathcal{N} \cup \mathcal{H}$ are that each MCI must: (i) Be consistent with the assertion, (ii) Include the projected presupposition itself. With this, our results follow (repeated here as (14)-(17)):

14. John believes it stopped raining

    - Asserted Sentence: $\phi = B_j S_r$
    - Projected Presupposition: $B_j r$

[23] $\{\neg K_j S_r, \neg S_r\}$ is the unique MCI in (13).

- Scalar Alternatives: $A(\phi) = \{B_jS_r, K_jS_r, S_r\}$
- Candidate Propositions for Implicature: $\mathcal{N} = \{\neg B_jS_r, \neg K_jS_r, \neg S_r\}$
- Candidate Propositions for Accommodation: $\mathcal{H} = \{B_jr, S_r \wedge K_jr, r\}$
- Maximal Consistent Inclusions: (i) $\{\neg K_jS_r, \neg S_r, B_jr, r\}$, (ii) $\{\neg K_jS_r, B_jr, S_r \wedge K_jr, r\}$
- Given our MCIs, the set of innocently includable propositions is: $\{\neg K_jS_r, B_jr, r\}$
- Thus, the only implicature is: $\neg K_jS_r$
- The accommodation is: $r \wedge B_jr$

15. Mary knows that John believes it was raining

    - Asserted Sentence: $\phi = K_mB_jr$
    - Projected Presupposition: B_jr
    - Scalar Alternatives: $A(\phi) = \{K_mB_jr,\ K_mr,\ B_jr,\ r,\ K_mK_jr,\ K_jr,\ B_mB_jr,\ B_mr,\ B_mK_jr\}$
    - Candidate Propositions for Implicature: $\mathcal{N} = \{\neg K_mB_jr, \neg K_mr, \neg B_jr, \neg r, \neg K_mK_jr, \neg K_jr, \neg B_mB_jr, \neg B_mr, \neg B_mK_jr\}$
    - Candidate Propositions for Accommodation: $\mathcal{H} = \{r, K_jr, B_mr, B_jr\}$
    - Innocently Includable Propositions: Given our constraints (consistency with assertion, and inclusion of semantic presuppositions), the only innocently includable propositions are: (i) B_jr, (ii) $\neg K_mr$, (iii) $\neg B_mK_jr$, (iv) $\neg K_mK_jr$
    - Since (iv) is entailed by (iii), our implicatures are (ii) $\neg K_mr$, and (iii) $\neg B_mK_jr$
    - The only accommodation is the semantic presupposition itself, (i) B_jr

Let us also make sure that our revised proposal for meaning enrichment still allows us to capture the data from conditional presuppositions:

16. If John flies to Toronto, his sister will pick him up from the airport

    - Asserted Sentence: S = if ϕ, then ψ_p
    - Projected Presupposition: $\phi \rightarrow p$
    - Scalar Alternatives: $A(S) = \{$ if ϕ then $\psi_p, \phi, \neg\phi, \psi_p, \neg\psi_p\}$
    - Candidate for Implicature: $\mathcal{N} = \{\neg(\phi \rightarrow \psi_p), \phi, \neg\phi, \psi_p, \neg\psi_p\}$
    - Candidates for Accommodation: $\mathcal{H} = \{\phi \rightarrow p, p\}$
    - Maximal Consistent Inclusions: (i) $\{\phi, \psi_p, \phi \rightarrow p, p\}$, (ii) $\{\phi, \neg\psi_p, \phi \rightarrow p, p\}$, (iii) $\{\neg\phi, \psi_p, \phi \rightarrow p, p\}$, (iv) $\{\neg\phi, \neg\psi_p, \phi \rightarrow p, p\}$
    - Innocently Includable Propositions: The only innocently includable propositions are the members of $\mathcal{H}$ itself, $\phi \rightarrow p$ and p, and since one of these propositions (p) entails the other, the accommodation is simply p

17. Mary knows that if John flies to Toronto, he has a sister

- Asserted Sentence: $S = K_m$(if ϕ, then ψ)
- Projected Presupposition: $\phi \rightarrow \psi$
- Scalar Alternatives: $A(S) = \{K_m$(if ϕ, then ψ), $K_m\phi$, $K_m\neg\phi$, $K_m\psi$, $K_m\neg\psi$, if ϕ then ψ, ϕ, $\neg\phi$, ψ, $\neg\psi\}$
- Candidates for Implicatures: $\mathcal{N}$ = $\{\neg K_\alpha(\phi \rightarrow \psi)$, $\neg K_\alpha\phi$, $\neg K_\alpha\neg\phi$, $\neg K_\alpha\psi$, $\neg K_\alpha\neg\psi$, $\neg(\phi \rightarrow \psi)$, ϕ, $\neg\phi$, ψ, $\neg\psi\}$.
- Candidates for Accommodation: $\mathcal{H} = \{\phi \rightarrow \psi, \phi, \neg\phi, \psi, \neg\psi\}$.
- Innocently Includable Propositions: $\{\neg K_\alpha\phi$, $\neg K_\alpha\neg\phi$, $\neg K_\alpha\psi$, $\neg K_\alpha\neg\psi$, $\phi \rightarrow \psi\}$
- Thus, the implicatures are: (i) $\neg K_\alpha\phi$, (ii) $\neg K_\alpha\neg\phi$, (iii) $\neg K_\alpha\psi$, (iv) $\neg K_\alpha\neg\psi$
- The only accommodation possibility is: $\phi \rightarrow \psi$

4 Concluding Remark

Having adopted innocent inclusion in place of the cancellation principle from Section 1, the question again arises: Is the relevant notion of consistency used by the enrichment algorithm sensitive to the common knowledge shared between speaker and hearer, or is the relevant notion logical? An answer to this question might bear on broader questions of the place of this enrichment system along the semantic/pragmatic divide. For some tentative arguments for thinking the system might be encapsulated from common knowledge, see Singh [43, 44].

5 Appendix: Summary of System

Suppose ϕ is asserted in context c. The implicatures and accommodated presuppositions in response to ϕ are computed as follows.

- generate the scalar alternatives to ϕ, $A(\phi)$

Scalar Alternatives Let ϕ be a parse tree. Then parse tree ψ is a scalar alternative to ϕ if ϕ can be transformed into ψ via a finite sequence of the following operations: (i) Deletion (removing edges and nodes from the tree), (ii) Contraction (removing an edge and identifying its edge nodes), (iii) Subsitution of structures for other structures from a substitution source.

Substitution Source The subsitution source for parse-tree ϕ is the union of the lexicon of the language with the set of all subtrees of ϕ.

- Generate candidate set of implicatures, $\mathcal{N} = \{\neg p : p = [[\psi]], \psi \in A(\phi)\}$
- Generate candidate set of accommodations, $\mathcal{H} = \{\pi(\psi) : \psi \in A(\phi)\}$
- Form $\mathcal{N} \cup \mathcal{H}$
- Find Maximal Consistent Subsets M_i of $\mathcal{N} \cup \mathcal{H}$ such that: (i) The conjunction of the propositions in each MCI is consistent with $[[\phi]]$, and (ii) $\pi(\phi)$ is in each MCI

- Form the intersection of each MCI, $M_1 \cap \ldots \cap M_k = \mathcal{I}$ (these are the innocently includable propositions)
- $r \in \mathcal{N}$ is a *scalar implicature* iff $r \in \mathcal{I}$
- $r \in \mathcal{H}$ is an *accommodated presupposition* iff $r \in \mathcal{I}$

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