Conversational implicature: interacting with grammar*

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Abstract Grice defined conversational implicatures as social, cognitively complex meanings that discourse participants create jointly in interaction. Grammar-driven accounts are framed in opposition to this view. I seek to mediate this debate. I describe a general framework for interactional models of implicature and then assess the major arguments for grammar-driven approaches. My central findings are that many of these arguments are conceptually or theoretically problematic, and that the valid ones do not compromise the Gricean picture. Stepping back, I find that the two sides in this debate are not really in opposition, but rather offer complementary insights.

Keywords: conversational implicatures, scalar implicatures, embedded implicatures, decision theory, Hurford's constraint

1 Introduction

Grice (1975) defined conversational implicatures as social, cognitively complex meanings that discourse participants create jointly in interaction. Recent grammar-driven accounts are framed in opposition to this conception, especially for scalar implicatures (SIs). For example, Chierchia, Fox & Spector (2012) write, "the facts suggest that SIs are not pragmatic in nature but arise, instead, as a consequence of semantic or syntactic mechanisms".

My primary goal is to mediate this debate. I begin by describing a class of related models that seek to make good on the Gricean characterization of implicatures, and then I review the grammar-driven account of Chierchia et al. (2012; henceforth CFS). With that theoretical background in place, I address the two major arguments that have been put forth in favor of grammar-driven views:

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(i) implicatures that seem to be semantically embeddable and (ii) implicatures that cooperative speakers cannot cancel.

It is widely assumed that the existence of semantically embedded implicatures would undermine the Gricean view, which derives implicatures as enrichments of semantic content. However, I argue that (in a surprising twist) CFS's theory diffuses this threat. CFS model the contextual variability of implicatures as ambiguities in the mapping from surface to logical form: certain arrangements of covert exhaustification operators lead to implicature-rich interpretations, and others do not. Embedded implicatures are simply those in which the operators are embedded. Griceans who embrace these logical forms can hold to their utterance-based, post-semantic position even if embedded implicatures turn out to be real. Moreover, embedded implicatures are still shaped by pragmatic forces (e.g., what is verifiable and relevant), so the Gricean's contributions remain vital.

I believe this theoretical synthesis is achievable but non-trivial; the existence of embedded implicatures would compel the Gricean to refashion all her explanations in terms of how speakers and listeners coordinate on logical forms using highly underspecified surface forms (and contextual information). Thus, I review the arguments for embedded implicatures in detail. They turn out to be a mixed bag in terms of their empirical accuracy and theoretical relevance: attitude embeddings, conditional antecedents, and Hurford's constraint offer no support for grammar-driven views, leaving only intrusive constructions and the seminal experimental results of Chemla & Spector (2011) as potential support.

Argument (ii) — uncancelable implicatures — seems to pose a greater threat to the Gricean. Implicatures depend for their very existence on contextual support, and we might expect cancelation to be a fail-safe way for the speaker to remove such support. Thus, this seems at first to be a case where the interactional view *misleads* us, predicting fewer implicatures than are attested. However, Hirschberg (1985) shows that cancelability does not follow from Grice's definition, and Eckardt (2007) and Lauer (2013) rely only on contextual and interactional dynamics to create uncancelable implicatures. Such accounts are arguably superior to those offered by grammar-driven views, which achieve uncancelable implicatures via special stipulations on allowable logical forms.

Stepping back, I find that the two sides in this debate are not really in opposition, but rather offer complementary insights. Grammar-driven accounts have helped to reveal that linguistic conventions (including intricate semantic operations) play a role in implicature calculation, and interactional accounts have made progress in explaining how those conventions work in context to yield conversational implicatures. Though much of this paper is devoted to criticizing arguments for grammar-driven accounts, my larger claim is that we should regard the two sides as part of the same cooperative research program.

2 Conversational implicature

This section reviews the original Gricean definition of conversational implicature and seeks to draw out its central consequences. I work with the version in def. 1.

Definition 1 (Conversational implicature)**.** Speaker S conversationally implicates q by uttering U to listener L in context C iff

i. It is a mutual, public presumption of S and L that S is cooperative in C at least insofar as communication is concerned.

ii. In order to maintain (i) in C given U, it must be supposed that S thinks q.

iii. S thinks that both S and L mutually, publicly presume that L is willing and able to work out that (ii) holds.

On this definition, from the listener's perspective, a conversational implicature is a social gesture, in that it reconciles speaker S's apparently uncooperative behavior with the prior assumption that S is cooperative (clause i). Clause iii brings in S's perspective, empowering her to leverage clauses i–ii in production.

Def. 1 seeks to adhere to Grice's (1975: 49–50) description (see also Levinson 1983: 113) while being more explicit about the agents and attitudes involved; the original can be maddening in its underspecification about these matters (Hirschberg 1985: §2). I've retained "thinks" in clause ii, though "intends to convey" often seems more apt for communication (Thomason 1990: 340) and more in keeping with Grice's (1989) broader theory of meaning. With "thinks", a speaker can implicate q even without intending to do so, which seems necessary. For example, Ariel (2004) discusses the bumper sticker "The majority decided for peace. Me too", which implicates that some decided against peace even though that partly undermines the intended message (Horn 2006: 37).

The notion of communicative cooperativity invoked in clause i needs to be supplied by a background pragmatic theory. I rely on Grice's (1975) cooperative principle and associated maxims (def. 2), but my arguments are compatible with other theories (Joshi 1982; Horn 1984, 1996; Levinson 1995, 2000; Sperber & Wilson 1995, 2004).

Definition 2 (Gricean pragmatics)**.**

> *The Cooperative Principle*: Make your contribution as is required, when it is required, by the conversation in which you are engaged.
>
> – *Quality*: Contribute only what you know to be true. Do not say false things. Do not say things for which you lack evidence.

- *Quantity*: Make your contribution as informative as is required. Do not say more than is required.
- *Relation (Relevance)*: Make your contribution relevant.
- *Manner*: (i) Avoid obscurity; (ii) avoid ambiguity; (iii) be brief; (iv) be orderly.

Example (1) illustrates implicature calculation in these terms. With the particular set of assumptions given, the speaker's weak scalar term gives rise to the implicature that its stronger alternatives are false.

(1) *A*: Sandy's work this term was satisfactory.

Implicature: Sandy's work was not excellent ($= \neg q$).

a. *Contextual premise*: the speaker *A* intends to give an exhaustive answer to a (perhaps) implicit question like 'What was the quality of Sandy's work this term?'

b. *Contextual premise*: *A* has complete knowledge of Sandy's work for the term (say, *A* assigned all the grades for the class).

c. Assume *A* is cooperative in the sense of def. 2.

d. The proposition q that Sandy's work was excellent is more informative than p, the content of *A*'s utterance.

e. Proposition q is (approximately) as easy to express in this context as p.

f. By (a), q is more relevant in this context than p.

g. By (c)–(f), *A* must lack sufficient evidence to assert q.

h. By (b), *A* must lack evidence for q because q is false.

This example highlights the central consequences of def. 1: context dependence, linguistic dependence, cognitive and interactional complexity, uncertainty, and post-semanticality. I review each in turn in secs. 2.1–2.5. Following that, I briefly address the delicate issue of cancelability (sec. 2.6) and then survey the theoretical landscape using this definition as a touchstone (sec. 2.7).

2.1 Context dependence

Context dependence is evident in the role that contextual premises (1a, b) play. For example, if we change the (overt or implicit) question in (1a) to 'Is Sandy's work satisfactory', then the implicature disappears: the stronger statement *Sandy's work is excellent* is no longer relevant, so (1f) fails, which

means that there is no tension between the literal content of *A*'s utterance and the cooperativity assumption (1c). More subtly, if we remove the *expert assumption* (1b) but leave everything else the same, then the reasoning goes only to (1g), rather than all the way to the stronger implicature in (1h).

2.2 Linguistic dependence

Def. 1 is largely silent on the matter of what (if any) language is being spoken. However, the maxim of manner exerts itself in (1e), and this suffices to create rich linguistic dependencies (McCawley 1978; Horn 1984; Levinson 2000; Blutner 1998, 2000). To see this in our example, suppose *satisfactory* is the only positive adjective of the requisite semantic class that *A* feels confident using in this context with this audience. Then (1e) fails. This failure provides an alternative explanation, besides a lack of evidence (1g), for why the speaker did not convey that Sandy's work was excellent, thereby (potentially) removing the implicature. Similarly, suppose we have the semantic grade/adjective associations

70–100: *satisfactory* 80–100: *good* 90–100: *excellent*

but *satisfactory* and *excellent* are the only two adjectives that *A* feels confident using. Then *A*'s utterance does not convey that Sandy's work was not good, because *A* has other reasons for avoiding this utterance. In practice, we encounter more subtle versions of this kind of ineffability, and the effects generally just cast doubt on implicatures rather than removing them, but these extreme cases suffice to show that implicature calculation is influenced by linguistic convention just as it is influenced by relevance, informativity, truth, and evidence.

2.3 Cognitive and interactional complexity

Def. 1 defines implicatures as cognitively and interactionally complex, in that they require deep reasoning in terms of the context, the semantics of the utterance, and the other agents' beliefs. If we stitch together all the attitude statements of clause iii, then we have four levels of embedding. These embeddings have a back-and-forth quality that makes implicature calculation an inherently collaborative process (Joshi 1982; Clark 1996).[1]

1 It's an important question whether this complexity impacts the prevalence of implicatures (Paris 1973; Hendriks, Hoeks, de Hoop, Krammer, Smits, Spenader & de Swart 2009; Geurts 2009) and the extent to which people find shortcuts to obtaining them (Grodner & Sedivy 2008; Grodner, Klein, Carbary & Tanenhaus 2010; Huang & Snedeker 2009). In the interest of concision, I must neglect these issues here.

2.4 Uncertainty

Hirschberg (1985) was, I believe, the first to emphasize the communicative uncertainty of implicatures. The above discussion of def. 1 reveals many reasons why this is an inherent property of these meanings. The presence and nature of implicatures will be affected by uncertainty about the context, the linguistic norms, the speaker's preferred way to resolve tensions in the maxims, the speaker's commitment to cooperativity, the speaker's ability to undertake the necessary reasoning, the listener's beliefs about the speaker's abilities, and so forth. All this uncertainty makes sense of why implicatures tend to be re-enforceable, that is, expressible with semantic content with little or no redundancy (Sadock 1978; Horn 1991; Levinson 2000): being explicit in that way reduces uncertainty by direct appeal to pre-established linguistic conventions.

2.5 Post-semanticality

The Gricean view is often characterized as 'post-semantic' because its implicatures are calculated in terms of literal semantic content; def. 1 begins with an utterance that we presume to have a fixed semantic content p, and implicatures are calculated as enrichments of p.

This property plays a central role in the arguments between Gricean and grammar-driven views, since it is regarded by many as eliminating the possibility of embedded implicatures. I address this in sec. 4. For now, I offer only a more general comment: independent of embedded implicatures, post-semanticality will have to be abandoned in light of the powerful psycholinguistic evidence that basically all aspects of interpretation are fast and incremental. This evidence calls for modifications to the grammar-driven views advanced here as well, since their logical forms are not designed for incremental interpretation either.

The challenge we all face is that incremental interpretation is governed by high-level pragmatic factors. For example, Sedivy (2007) and Grodner & Sedivy (2008) show that listeners draw contrastiveness implicatures for modified noun phrases as soon as they hear the attributive modifiers, suggesting a fast local process. However, Grodner & Sedivy also show that this process is influenced by the listener's beliefs about the speaker, suggesting a high-level, deliberative process like def. 1 (see also Piantadosi, Tily & Gibson 2011).

2.6 Cancelability

Cancelability is often regarded as a defining feature of implicatures. However, it is not *literally* a defining feature, in the sense that it is not a consequence of

Grice's (1975) definition (def. 1) that all implicatures will be cancelable. The definition seems to leave room for cancelation in particular cases, but it does not ensure it for all. Hirschberg (1985) shows this in detail.[2] Grice (1975) is, as always, cagey about the issue. He writes:

> Since, to assume the presence of a conversational implicature, we have to assume that at least the Cooperative Principle is being observed, and since it is possible to opt out of the observation of this principle, it follows that a generalized conversational implicature can be canceled in a particular case.

I tend to read this as saying that implicatures are invariably cancelable. If that was Grice's intention, then he was mistaken about the consequences of his definition. However, there is (perhaps) a reading of this quotation that gets things right. Cancelation always compromises the speaker's cooperativity to some degree. In many cases, this is tolerable, but, if the compromises are too great, we sound the alarm that the speaker's verbal behavior is uncooperative to the point of infelicity, i.e., that cancelation is not an option.

2.7 The theoretical landscape

To close this background section, I offer, in fig. 1, a rough picture of the theoretical landscape with regard to implicatures, at least as I understand it. The x-axis very informally measures theories by how much they rely on the grammar. The y-axis very informally measures them by how much they require interaction between agents. Some of the classifications are perhaps not what is expected. For example, Grice (1975) is not the purest example of what one might take to be the Gricean perspective on which all implicatures are calculated in context using a procedure or inference process like def. 1. That honor goes to Noncism. Grice (1975: 56) compromised by saying, fairly forthrightly, that many generalized implicatures are what Levinson (2000) calls 'presumptive meanings'.

The 'Implicature/Explicature' label groups the Relevance theorists and Kent Bach. Their position near the middle of the 'grammar-driven' scale might seem surprising, since they advocate thoroughly pragmatic views of implicature. However, they exclude most scalar inferences from the class of implicatures, treating them instead as elaborations of logical form (*impliciture* for Bach, *explicature* for the Relevance theorists), which makes them resemble grammar-driven accounts for this narrow piece of the pie.

2 If we adopt a more intention-driven definition, then cancelation seems downright irrational, since the speaker must have an intention solely for the purposes of denying it (Hirschberg 1985: 27).

For the most part, I am concerned with the position of Logical Forms views. I believe they are implicitly much higher on the interactional axis than they are advertised as being. I believe my arguments also suggest that we needn't go farther to the right than the neo-Griceans have, but I wouldn't be surprised if I had to give this up, say, based on intrusive constructions (sec. 5.4) or experiments like those in Chemla & Spector 2011 (sec. 5.5). In other words, the dashed arrow in fig. 1 summarizes my central thesis.

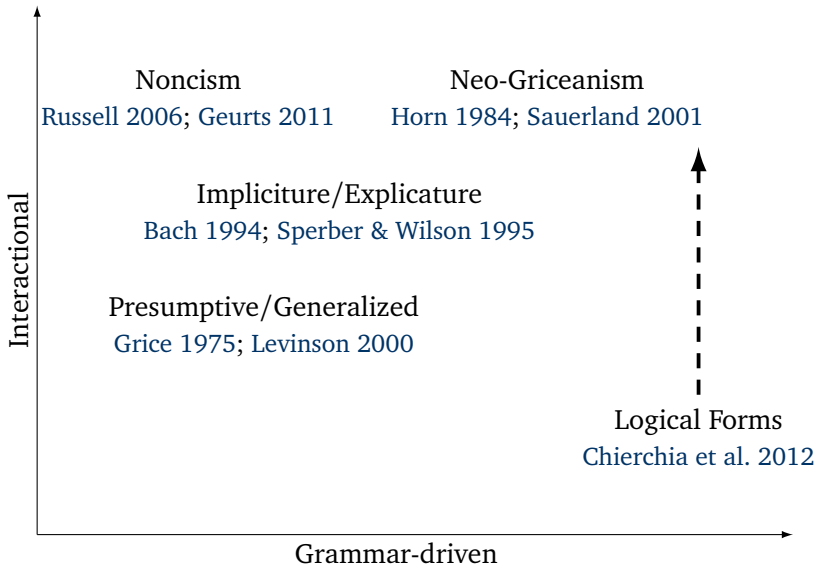


Figure 1 A rough map of the theoretical landscape, with representative citations. The dashed arrow summarizes my thesis.

3 Interactional models

This section describes a framework that I think is capable of doing justice to the above Gricean conception of conversational implicatures. The model itself is bare-bones, but it is easily embedded in a larger model of sequential decision-making under uncertainty in which language and action are brought together.[3]

Def. 3 gives the basic structures:

3 This framework is not my own, but rather synthesizes proposals by van Rooy (2003), Benz (2005), Franke (2008, 2009), Jäger (2007, 2012), Frank & Goodman (2012), and Goodman & Lassiter (To appear), which are based on pioneering work by Lewis (1969, 1975), Clark (1996), Merin (1997), and Parikh (2001). The presentation largely follows that of Bergen, Goodman & Levy 2012.

Definition 3 (Communication games)**.** A communication game is a structure $(T, M, [\![\cdot]\!], P, C)$, where

i. T is a set of states (worlds, referents, propositions, etc.).

ii. M is a set of messages.

iii. $[\![\cdot]\!] : M \mapsto \wp(T)$ is a semantic interpretation function.

iv. $P : T \mapsto [0,1]$ is a prior probability distribution over states.

v. $C : M \mapsto \mathbb{R}$ is a cost function on messages.

Communication games model production and interpretation. The speaker observes a state t and chooses a message m based on t and the message costs C. The listener chooses a state t' based on m and her prior expectations P about the state. I assume the discourse participants know the structure of their communication game, which comes down to them knowing what language they are speaking (M and $[\![\cdot]\!]$), what the context is like (the prior P), and the costs C associated with communication. I assume throughout that the speaker will choose a message that has maximum probability given the state, and that the hearer will choose a state that has maximum probability given the speaker's message. This amounts to the assumption that the speaker and hearer would like to communicate, which might or might not be tied up with their real-world goals (see Franke, De Jager & van Rooij 2009; Asher & Lascarides 2013).

Production and interpretation can be modeled as a recursive process in which the speaker and listener reason about each other reasoning about each other. Suppose we begin with a truth-conditional listener l: given message m, l guesses a state $t \in [\![m]\!]$ based only on the prior. The speaker s can model this truth-conditional listener in production, anticipating her inferences and trying to respond in a way that maximizes the chances of successful communication. What's more, l can plan for this kind of sophisticated speaker and make her inferences accordingly. And so forth. Alternatively, the recursive process can begin with a speaker who, given a state t, chooses messages based on $[\![\cdot]\!]$ and the cost function. In either case, the process can proceed until the system stabilizes or until the participants reach the limits of their rationality, mental energy, or commitment to the cause (Camerer, Ho & Chong 2004; Franke 2008, 2009; Jäger 2007, 2012).

This recursive system is defined by two general agents, which are just functions mapping conditional distributions into conditional distributions. A listener agent applies Bayes' theorem to turn a production distribution $s(m \mid t)$ into a probabilistic interpretation function that balances the content of the messages with the prior values $P(t)$:

Definition 4 (Listener)**.** A listener for communication game $(T, M, [\![\cdot]\!], P, C)$ is a function L such that, for any conditional distribution s over M and T,

$$L(s) = l \text{ such that for all } t \in T \ \& \ m \in M, l(t \mid m) = \frac{s(m \mid t)P(t)}{\sum_{t' \in T} s(m \mid t')P(t')}$$

A speaker agent is a function from listener distributions $l(t \mid m)$ into production distributions $s(m \mid t)$. The general concept is the same as for the listener agent, except that we need to map the real-valued costs into probability space:

Definition 5 (Speaker)**.** A speaker for communication game $(T, M, [\![\cdot]\!], P, C)$ is a function S such that, for any conditional distribution l over T and M,

$S(l) = s$ such that for all $m \in M$ & $t \in T$,

$$s(m \mid t) = \frac{\exp\left(\log(l(t \mid m)) - C(m)\right)}{\sum_{m' \in M} \exp\left(\log(l(t \mid m')) - C(m')\right)}$$

Where the costs are all 0, the reduces to $l(t \mid m) / \sum_{m'} l(t \mid m')$ by the identity $x = \exp(\log(x))$. Similarly, if the costs are scaled into $[0, 1]$, then the values can be given as a product of the listener probabilities and the costs, analogously to the listener in def. 4.

As I noted above, the recursive process can begin with either the speaker or the listener.[4] S_0 is the initial speaker; given a state t, it chooses a message m such that $t \in [\![m]\!]$, taking costs into account:

Definition 6 (Initial speaker)**.** The initial speaker for communication game $(T, M, [\![\cdot]\!], P, C)$ is

$$S_0(m \mid t) = \frac{\exp\left(\log\left(\frac{\mathbb{I}(t \in [\![m]\!])}{N}\right) - C(m)\right)}{\sum_{m' \in M} \exp\left(\log\left(\frac{\mathbb{I}(t \in [\![m']\!])}{N}\right) - C(m')\right)}$$

where $N = |\{m \in M : t \in [\![m]\!]\}|$.

The initial listener is L_0; given a message m, it guesses a state $t \in [\![m]\!]$, taking the prior probabilities into account:

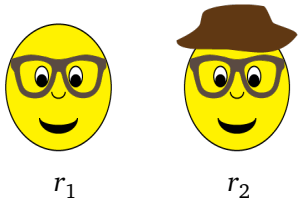
Definition 7 (Initial listener)**.** The initial listener for communication game $(T, M, [\![\cdot]\!], P, C)$ is

$$L_0(t \mid m) = \frac{\frac{\mathbb{I}(t \in [\![m]\!])}{|[\![m]\!]|} P(t)}{\sum_{t' \in T} \frac{\mathbb{I}(t' \in [\![m]\!])}{|[\![m]\!]|} P(t')}$$

4 For these definitions, $\mathbb{I}$ is an indicator function: $\mathbb{I}(\varphi) = 1$ if φ is a true statement, else 0.

3.1 A simple reference game

Fig. 2 depicts a basic scenario designed to illustrate how these agents interact to create pragmatically rich signals. The scenario depicted is a reference game of the sort developed initially by Rosenberg & Cohen (1964) and used increasingly in cognitive psychology, pragmatics, and natural language processing to study basic communicative processes and norms.[5] The speaker is randomly assigned one of the references (states) $r^* \in \{r_1, r_2\}$, with the identity of r^* known to the speaker but hidden from the listener. Using only the set of messages $M = \{\text{'hat'}, \text{'glasses'}\}$, the speaker helps the listener to identify r^*. For now, I assume a flat prior over states (fig. 2(c)) and cost-free messages (fig. 2(d)). I will shortly modify these assumptions to highlight the model's sensitivity to context and language.



r_1 r_2

(a) Scenario.

	'hat'	'glasses'
r_1	F	T
r_2	T	T

(b) $[\![\cdot]\!]$

r_1	0.5
r_2	0.5

(c) P

'hat'	0
'glasses'	0

(d) C

Figure 2 A communication game supporting a scalar implicature.

The scenario in fig. 2 supports an abstract, context-dependent scalar implicature: the specific term 'hat' asymmetrically entails the general term 'glasses' (fig. 2(b)). The theory of implicature leads us to expect that a cooperative speaker will use 'glasses' only where the more specific term 'hat' is false: message costs are all the same, and the speaker knows the identity of her referent, so this reduces to an interaction between the maxims of quantity and quality (def. 2). The scalar inference goes through easily for the interpreter as well: because it is a mutual, public supposition that the speaker knows the identity of r^* (the expert assumption), the listener will infer from the speaker's use of 'glasses' that 'hat' is infelicitous because it is false.

Fig. 3 shows a pair of speaker and listener agents playing the game. The process begins with S_0 as in def. 6. This agent is purely literal: given r_1, it

5 Clark & Wilkes-Gibbs 1986; Dale & Reiter 1995; Keysar, Barr, Balin & Brauner 2000; DeVault & Stone 2007; Heller, Grodner & Tanenhaus 2008; Krahmer & van Deemter 2012; Golland, Liang & Klein 2010; Degen & Franke 2012; Frank & Goodman 2012; Rohde, Seyfarth, Clark, Jäger & Kaufmann 2012; Bergen et al. 2012; Stiller, Goodman & Frank 2011.

plays each message with equal probability. The listener L responds to create $L(S_0)$, which captures the interpretive side of the target scalar implicature: a bias for choosing r_1 when told 'glasses'. The speaker can model such a listener, giving $S(L(S_0))$, which captures the production side of the implicature: a bias for choosing 'hat' where it is true. The biases evident at this stage are amplified by additional iterations; fig. 3(c) tracks this trend for the listener.

	'hat'	'glasses'
r_1	0	1
r_2	0.5	0.5

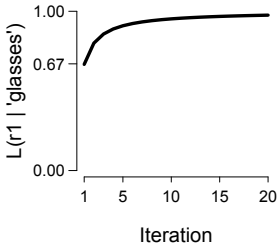
(a) S_0

	r_1	r_2
'hat'	0	1
'glasses'	0.67	0.33

(b) $L(S_0)$

	'hat'	'glasses'
r_1	0	1
r_2	0.75	0.25

(c) $S(L(S_0))$



(d) Highlighted values in tab. (b) up to 20 L/S alternations.

Figure 3 The fig. 2 implicature in production and interpretation.

Though I have not done systematic human-subjects experiments on this scenario, I now use this example to introduce the concept of conversational implicature in my introduction to semantics and pragmatics at Stanford, and this has generated some supporting data. Students play these reference games prior to the lesson on implicature, and then we discuss the results as part of the lesson. In my most recent such in-class experiment, participants in the production condition chose the pragmatic message (e.g., 'hat' when given r_2) in 237/240 instances (99%), and participants in the interpretation condition chose the pragmatic referent (e.g., r_1 when given 'glasses') in 151/160 instances (94%). The experiment included a variety of referents and message combinations, so we can be reasonably sure that this result is due to pragmatic reasoning, rather than to uneven priors or message costs (though the small size of the experiment leaves open that these could be confounding factors).[6] The result is also bolstered by the comparable results for similar scenarios (with much more careful methodology) reported in Stiller et al. 2011.

6 For the materials, raw results, and a more detailed analysis: http://www.stanford.edu/class/linguist130a/materials/ling130a-survey-02-07-implicature.zip.

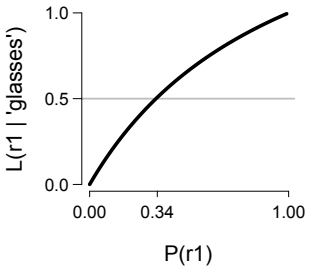
3.2 Reference game variations and the properties of implicature

As in the more free-form example (1), changes to this scenario help to reveal how the model captures the defining properties of implicatures reviewed in sec. 2 above: context dependence, linguistic dependence, cognitive and interactional complexity, uncertainty, and post-semanticality.

The primary source of context dependence in these models is the prior P over states. States that participants have decided to eliminate from consideration can be assigned 0 or near-0 probability, with the remaining states forming a probabilistic common ground. Even the simple faces game illustrates how this can affect implicature calculation, as fig. 4 shows. The left panel gives the $L(S_0)$ inference with a prior that biases in favor of r_2. The implicature we saw in fig. 3(b) has been washed out by the prior bias for r_2. Fig. 4(b) generalizes this, showing the values for all possible priors; the horizontal gray line at 0.5 marks the point at which the prior creates a bias in favor of the implicature of fig. 3.

	r_1	r_2
'hat'	0	1
'glasses'	0.46	0.54

(a) $L(S_0)$ for $P(r_1) = 0.3$.



(b) Highlighted values in tab. (a) for all $P(r_1)$. At $P(r_1) = 0.34$, the bias goes towards the implicature.

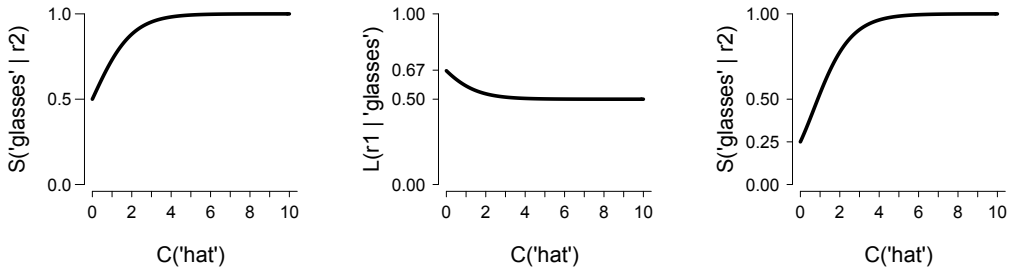
Figure 4 The influence of the prior on the implicature of fig. 3(b).

This role for the prior is not an idle mathematical fact. In the experiments of Frank & Goodman (2012), which involve more complex reference scenarios than fig. 2, potential implicatures are eliminated by the prior, which Frank & Goodman measure experimentally. Conversely, Stiller et al. (2011) show that certain priors have a positive effect on whether children draw particularized implicatures.

The models above can also be combined with even richer notions of context dependence. For example, Franke (2009) extrapolates an abstract issue or Question Under Discussion (QUD) from the structure of a communication game like the above. That QUD then provides another, equivalent perspective on

the agents' preferences and communicative behavior. To imbue the QUD with even more influence, it could be stipulated externally (perhaps as part of a general theory of context; Groenendijk & Stokhof 1984; Rooth 1985; Lewis 1988; Ginzburg 1996; Roberts 1996; Büring 1999; Ginzburg & Sag 2001; Rojas-Esponda 2012), thereby further shaping the implicatures.

We saw in secs. 2.1–2.2 that context dependence and linguistic dependence are similar on the Gricean account. The same is true here; whereas context dependence stems primarily from the prior P, linguistic dependence stems primarily from the costs C. For example, in the faces scenario, high costs on 'hat' remove the scalar implicature. Fig. 5 shows how this happens. All three panels track costs for the message 'hat' for values 0 to 10. For the initial speaker (fig. 5(a)), we begin in the same place as in fig. 3(a). However, as the costs rise, the message 'glasses' becomes associated with r_2, the referent with both the glasses and the hat. (Of course, 'glasses' is also associated with r_1, since that is the only message true of r_1.) This change to the initial speaker profoundly affects the listener (fig. 5(b)): the implicature that was present with C('hat') (as in fig. 3(b)) disappears. In turn, speaker $S(L(S_0))$ chooses 'glasses' for r_2 (and r_1) for nearly all costs, since it anticipates these other biased agents.



(a) S_0 (b) $L(S_0)$ (c) $S(L(S_0))$

Figure 5 High costs for 'hat' remove the implicature of fig. 3.

All the above examples show how implicatures can be amplified or dampened when the agents reason about each other. Such cognitive and interactional complexity is perhaps the model's tightest link to Grice 1975. The simple scalar example above does not really draw this out, since the target implicature is present even for the $L(S_0)$ listener (though fig. 3(c) shows that it becomes a near-categorical inference only after about five iterations). To see how powerful deep iterative reasoning can be, let's look briefly at fig. 6, the variant of Frank & Goodman's (2012) scenario used in Vogel, Potts & Jurafsky 2013b. Assume

that the prior over the referents is flat and all messages have 0 cost. Then the progressively more complex agents proceed as in figs. 6(c)–6(f). In the in-class experiment described above, participants associated r_2 with 'glasses' (fig. 6(f)) in only 86/120 cases (57%). We can account for this easily by making an assumption of *bounded rationality* (Camerer et al. 2004; Franke 2008, 2009): in the experimental scenario, participants in the listener condition mostly reasoned to $L(S_0)$, only occasionally if ever going to $L(S(L(S_0)))$.

r_1 r_2 r_3

(a) Scenario.

	'hat'	'glasses'	'mustache'
r_1	F	F	T
r_2	F	T	T
r_3	T	T	F

(b) $[\![\cdot]\!]$

	'hat'	'glasses'	'mustache'
r_1	0	0	1
r_2	0	0.5	0.5
r_3	0.5	0.5	0

(c) S_0

	r_1	r_2	r_3
'hat'	0	0	1
'glasses'	0	0.5	0.5
'mustache'	0.67	0.33	0

(d) $L(S_0)$

	'hat'	'glasses'	'mustache'
r_1	0	0	1
r_2	0	0.6	0.4
r_3	0.67	0.33	0

(e) $S(L(S_0))$

	r_1	r_2	r_3
'hat'	0	0	1
'glasses'	0	0.64	0.36
'mustache'	0.71	0.29	0

(f) $L(S(L(S_0)))$

Figure 6 A complex faces scenario. The $S(L(S_0))$ agent does not interpret 'glasses' pragmatically, but the $L(S(L(S_0)))$ agent does.

Bounded rationality is a source of uncertainty in these models as well. Fig. 6 shows that iteration can create production and interpretation preferences. In general, discourse participants will not know how deeply their interlocutors (or even they themselves) are willing to go, so speakers will often be unsure whether their intended implicatures were perceived (is my listener insightful enough?), and listeners will often be unsure whether the speaker endorses the inferences they reach (is the speaker sufficiently astute?). This uncertainty is compounded by the fact the inferences in question rarely achieve certainty (probability 1), even under arbitrarily deep iteration. For the most part, doubt adheres to all pragmatic extrapolations from the shared communication game.[7]

7 Uncertainty about the priors and costs is an intuitive source of uncertainty, but the model doesn't capture them, since it assumes that the agents know the structure of their communication game. However, uncertainty here could be captured by treating the game as a feature of the common ground, as in Thomason 1990 and Stone, Thomason & DeVault 2007.

Finally, like the Gricean model, this one seems accurately characterized as post-semantic. In fact, it generalizes that idea: each successively higher (more pragmatic) level is derived from a more literal lower level. For example, L_0 is semantic (with context dependence from the prior), and $L(S(L_0))$ is a pragmatic agent derived from it. This has been taken as ruling out the possibility of embedded implicatures. However, as I mentioned above, the ambiguist CFS account paves the way to capturing them. I discuss this more fully in sec. 4. First, though, I digress slightly to relate the above to other influential new models.

3.3 Related models

A number of recent models are definable in the above terms:

Golland et al. (2010) These authors use a model that is equivalent to $L(S_0)$. They learn the relevant probability distributions from a specialized corpus and do some probabilistic semantic composition in the messages.

Frank & Goodman 2012 These authors go one step deeper than Golland et al., to give a model that is equivalent to $L(S(L(S_0)))$. However, they incorporate the prior only for the outer listener. This model is able to capture implicatures that a simpler model cannot, as we saw in fig. 6, in which $L(S_0)$ is purely truth-conditional for 'glasses' (fig. 6(d)), whereas $L(S(L(S_0)))$ achieves a strong bias for interpreting this message as referring to r_2 (fig. 6(f)).

Best Response models The agents of Franke (2008, 2009) and Jäger (2007, 2012) have the same basic structure as the ones defined above, except all non-maximal values are sent to 0, thereby returning even distributions over the maximal values. This removes much of the uncertainty about the inferences and also leads the prior distribution to behave very differently than it does in the model defined here. Fig. 7 illustrates with our simple faces game; compare the leftmost panel with the comparable one for fig. 2.

Decentralized POMDPs Vogel, Bodoia, Potts & Jurafsky (2013a) and Vogel et al. (2013b) embed $L(S(L_0))$ and $L(S_0)$ in a multi-agent model of sequential decision making under uncertainty called the Decentralized Partially Observable Markov Decision Process (Dec-POMDP; Bernstein, Givan, Immerman & Zilberstein 2002). Their artificial agents solve a simple collaborative task (Potts 2012) by learning efficient behavior and effective (pragmatically rich) communication. The experiments show that the kind of nested-belief model of communication defined by Grice leads to success more reliably and efficiently than a simpler one in which the agents do not try to model each other.

	'hat'	'glasses'
r_1	0	1
r_2	0.5	0.5

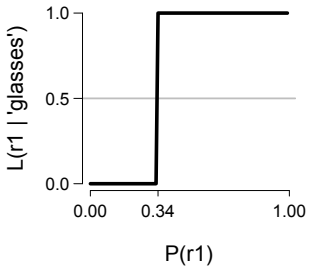
(a) S_0

	r_1	r_2
'hat'	0	1
'glasses'	1	0

(b) $L^{\text{br}}(S_0)$

	'hat'	'glasses'
r_1	0	1
r_2	1	0

(c) $S^{\text{br}}(L^{\text{br}}(S_0))$



(d) Highlighted values in tab. (b) for all $P(r_1)$

Figure 7 Best-response listener inferences for the fig. 2 faces game. The listener L^{br} is like def. 4 but sets all non-maximal values to 0 before normalizing, resulting in a hard shift to implicatures; cf. fig. 4(b).

4 Grammar-driven models

This section briefly reviews the grammar-driven model of CFS (Chierchia et al. 2012). As with my review of interactional accounts, I provide only a skeletal formulation, relying on citations to the literature to flesh this out. There are two central pieces to CFS's account: a generally available function *ALT* that maps denotations to their alternatives, and a covert exhaustification operator O.

For *ALT*, the relevant notion of alternative is familiar from theories of questions and focus (Groenendijk & Stokhof 1984; Rooth 1985, 1992): we can assume, as a default, that the alternatives for a meaning t are some subset of the items in the same type-theoretic denotation domain as t. One can also imagine variants of this proposal in which *ALT* operates over lexical items, rather than denotations, but the denotational view will suffice here. The function *ALT* is part of context-dependent semantics: the discourse participants need to coordinate on it just as they need to coordinate on the meanings of deictic or discourse-bound pronouns, ellipsis sites, evaluation standards, and the like.

The basic exhaustification operator is given in def. 8 (Spector 2007; Fox 2007, 2009; Magri 2009; Chierchia et al. 2012).[8]

Definition 8 (Exhaustification operator O)**.**

$$O_{ALT}(p) = p \wedge \forall q \in ALT : (p \not\sqsubseteq q) \sqsubseteq \neg q$$

8 This is not the operator that those authors ultimately favor, since it requires some implicit restrictions on allowable *ALT* functions in order to get the right inferences. The final version has the same form as def. 8 but further restricts *ALT* to alternatives that are *innocently excludable*.

The O operator maps a meaning p to one that entails p but excludes all of the expressions that p does not entail. When dealing with truth-functional expressions, we can regard $\sqsubseteq$ as entailment, but the definition should be thought of as broad enough to include any kind of partial ordering, which Hirschberg (1985: §4) shows to be needed to capture the full range of 'scalar' implicatures.

Part of the case for a grammar-driven view is that it uses pieces of semantic theory that are independently useful. In particular, exhaustification is at the heart of Groenendijk & Stokhof's (1984) theory of questions and their answers (see also McCarthy 1980). The above operator is a common proposal for the meaning of *only* (for discussion: Rooth 1996; Büring & Hartmann 2001; Beaver & Clark 2008). Schulz & van Rooij (2006) use exhaustification for implicature calculation (see also de Jager & van Rooij 2007). (For critical discussion, see Alonso-Ovalle 2008 and Gajewski 2012.)

Those are the technical pieces. The proposal can then be summarized easily: O operators can appear anywhere in the logical form of a sentence, perhaps subject to additional restrictions and general preferences (see CFS: §4.6).

4.1 An illustration

The following is a simple illustration involving truth-functional expressions. The summary is that if we assume the alternative set for *or* ($\vee$) contains just *and* ($\wedge$), then exhaustification of *or* yields an exclusive disjunction ($\bar{\vee}$).

(2) a.

	p	q	$p \wedge q$	$p \vee q$	$p \,\bar{\vee}\, q$
w_1	T	T	T	T	F
w_2	T	F	F	T	T
w_3	F	T	F	T	T
w_4	F	F	F	F	F
	$\{w_1, w_2\}$	$\{w_1, w_3\}$	$\{w_1\}$	$\{w_1, w_2, w_3\}$	$\{w_2, w_3\}$

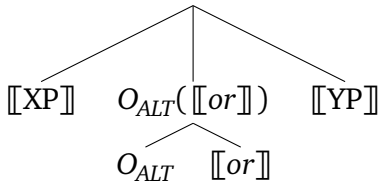
b. $ALT(\{w_1, w_2, w_3\}) = \{\{w_1\}\}$

c. $$\begin{aligned} O_{ALT}(\{w_1, w_2, w_3\}) &= \{w_1, w_2, w_3\} \cap (W - \{w_1\}) \\ &= \{w_1, w_2, w_3\} \cap \{w_2, w_3, w_4\} \\ &= \{w_2, w_3\} \end{aligned}$$

With the above, we can have syntactic constituents like (3), which encodes a pragmatically enriched disjunction like (2c). This constituent is predicted to have the basic morphosemantic distribution of any other disjunction. Thus, embedded

implicatures are predicted to be possible. Sec. 5 contains additional examples of how these meanings interact with the compositional semantics.

(3)



4.2 Implicit interactionality

As I noted in the introduction, CFS draw a firm rhetorical distinction between their proposal and the Gricean approach to pragmatics. They state, "the goal of this paper is to challenge the neo-Gricean approach to SIs", and later they write:

> the facts suggest that SIs are not pragmatic in nature but arise, instead, as a consequence of semantic or syntactic mechanisms

However, these absolutist statements are tempered by CFS's pervasive appeals to Gricean reasoning. The authors' specific examples are generally placed in contexts that support the target implicatures by ensuring that they are relevant, informative, and truthful. They concede that "aspects of the Gricean picture are sound and effective". And, in summarizing their account, they make explicit the role that Gricean pragmatics must play in helping discourse participants to coordinate on the right logical forms:

> one can capture the correlation with various contextual considerations, under the standard assumption (discussed in the very beginning of this paper) that such considerations enter into the choice between competing representations (those that contain the operator and those that do not).

It is no surprise, then, that essentially all the properties of implicature that I discussed in sec. 2 and sec. 3.2 are predicted to hold on CFS's theory as well. The major source of context and linguistic dependence in the model is the function *ALT*. The discourse participants must coordinate on this function. How this happens has not been a focus of grammar-driven accounts, but the above quotation suggests that communicative pressures like def. 2 guide the process. Similarly, because the language permits silent, embedded *O* operators in many positions, the speaker's signal always underdetermines her intended message; a given surface form *U* might be consistent with logical forms that convey implicatures and those that don't. The speaker must therefore rely on the listener

to select the right one. All these factors come together to ensure that implicatures will be uncertain in Hirschberg's (1985) sense.

From this perspective, implicature calculation amounts to reasoning about which logical form was intended. To see how this might work, let's return to example (1), in which speaker A utters U = "Sandy's work was satisfactory". Assume the lexicon has just three alternatives to *satisfactory* (*satisfactory*, *good*, and *excellent*), and that *ALT* is lexically constrained. Then U is consistent with the logical forms listed informally in (4).[9]

(4) Sandy's work was

a. $[\![satisfactory]\!]$

b. $O_{ALT([\![satisfactory]\!])=\{[\![excellent]\!]\}}([\![satisfactory]\!])$

c. $O_{ALT([\![satisfactory]\!])=\{[\![good]\!],[\![excellent]\!]\}}([\![satisfactory]\!])$

To decide among these options, the listener will go through exactly the reasoning in (4), except with the comparisons between meanings replaced by comparisons between these logical forms. Contexts favoring (4c) support the basic implicature derived in (1). LF (4b) would likely be favored in scenarios like those of sec. 2.2, in which the speaker has reason to avoid specific terms, say, out of a fear of misconstrual. As I said above, this suggests a synthesis between the two approaches. I suspect a complete synthesis will be more challenging than this basic example suggests, so it is worth asking how much motivation there is for a theory of implicature that is based in reasoning about O and *ALT*. The next section pursues this issue.[10]

5 Apparently embedded implicatures

This section reviews a variety of arguments for embedded implicatures. It's not the full set arguments that have been put forth for grammar-driven accounts, but I think it is a useful and representative sample.

9 Where $O_{ALT([\![satisfactory]\!])}$ is empty or contains only $[\![satisfactory]\!]$, the result is equivalent to (4a). Including $[\![satisfactory]\!]$ in *ALT* doesn't change the computation, since it is the weakest term. Similarly, the value set $\{[\![good]\!]\}$ is equivalent to (4c) assuming *excellent* entails *good*.

10 Is the theory of CFS post-semantic? Because logical forms like (3) can be part of much larger structures, one is inclined to answer no. In this sense, the theory is distinguished from the interactional one of sec. 3. However, I'm inclined to say that CFS don't really engage the question of post-semanticality, since they doesn't pursue the question of how discourse participants reason about the relationship between surface forms and logical forms. Their focus is simply elsewhere.

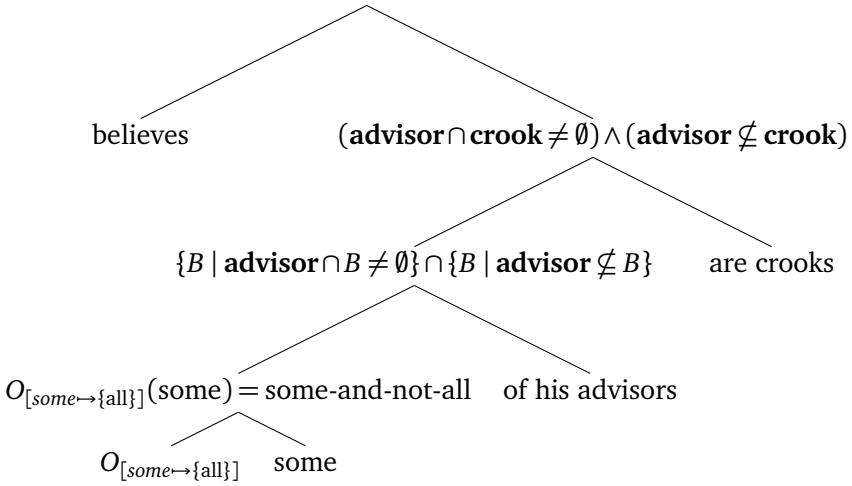
5.1 Attitude embedding

Chierchia (2004) gave the first sustained argument for embedded implicatures. One of his central empirical arguments concerns examples in which the embedded semantic argument to an attitude predicate seems to be pragmatically enriched, as in (5), from Russell 2006.

(5) George believes that some of his advisors are crooks.
Implicature: George believes not all of his advisors are crooks.

Expressing the implicature this way strongly suggests that the embedded scalar term is locally enriched, with the resulting semantic–pragmatic hybrid incorporated into the attitude predication. The grammatical analysis described above can deal with this handily, via an embedded O operator modifying *some*:

(6)



The implicature here seems robust, which might seem worrisome for an interactional view like the one in sec. 3, in which implicatures are calculated in terms of literal content. However, Russell (2006) shows that these examples can be captured on even the most basic Gricean account. The following calculation summarizes his argument:

(7) a. *Contextual assumption*:
G. believes all his advisors are crooks ∨
G. believes not all his advisors are crooks $(p \vee q)$

b. *Standard Gricean implicature*:
not(G. believes all of his advisors are crooks). $\neg p$

c. From (a)–(b) and disjunctive elimination:
G. believes not all of his advisors are crooks. q

Russell goes on to argue convincingly that this implicature is absent in contexts in which the 'opinionated' assumption (7a) is not met. He works systematically through all of the cases that Chierchia (2004) uses to motivate an embedded account, showing that they admit of the same kind of analysis as in (7) and that they manifest similar kinds of context sensitivity. See also Geurts 2009.

What ramifications does this have for deciding between grammar-driven and interactional views? The Gricean cannot rule out the availability of (6), and the grammaticist cannot rule out the availability of (7). However, crucially, even for the grammaticist, the issues are pragmatic: under what conditions will the speaker believe or intend a logical form like (6), and under what conditions will the listener recognize that? To understand what factors guide that process, we should ask whether premises like (7a) are mutual, public suppositions of the discourse participants. Stepping back, then, we see that, as discussed in sec. 4.2, the grammaticist account presumes ambiguity of logical form and calls on a pragmatic theory to explain how that ambiguity affects communication.

5.2 Conditional antecedents

One of the most widely endorsed arguments for intrusive implicatures comes from conditional antecedents. CFS give the argument using examples like (8).

(8) If you take phonology or semantics, you attend meeting A. If you take both, you attend meeting B.

Implicature: If you take phonology or semantics **but not both** ...

CFS observe that, if we interpret the disjunctive antecedent inclusively and assume a material conditional, the example is contradictory:

(9)
a. $(phono \vee sem) \rightarrow a$
b. $(phono \wedge sem) \rightarrow b$
c. $(a \wedge b) \rightarrow \bot$
d. By $(phono \wedge sem) \rightarrow (phono \vee sem)$ & transitivity: $(phono \wedge sem) \rightarrow a$
e. By (b) and (d): $(phono \wedge sem) \rightarrow (a \wedge b)$
f. By (c), (e) & transitivity: $(phono \wedge sem) \rightarrow \bot$

However, if we exhaustify the disjunctive antecedent clause using the *O* operator, yielding a conditional antecedent like (3), then the sentence has the semantics $(phono \bar{\vee} sem) \rightarrow a$, in which $\bar{\vee}$ is exclusive disjunction (see (2a)) and the incompatible outcomes are avoided.

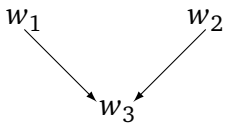
This seems like a powerful argument in favor of embedded implicatures, but it depends crucially on the problematic assumption that natural language conditionals are material conditionals. Lassiter (In progress) shows that if we assume a Kratzer–Lewis analysis of conditionals (Lewis 1973; Kratzer 1986), then there is no problem. One version of that analysis is given informally in (10).

(10) If you take phonology or semantics, you attend meeting A.

a. From the worlds that verify $[\![phono \vee sem]\!]$, select the subset X of worlds that are most similar to the actual world.

b. Truth conditions: $[\![meeting\ a]\!](w) = \top$ for all $w \in X$.

With the similarity ordering in fig. 8(a) and the truth conditions in fig. 8(b), the antecedent of *If you take phonology or semantics, you attend meeting A* quantifies only over $\{w_1, w_2\}$. In contrast, *If you take phonology and semantics, you attend meeting B* quantifies only over $\{w_3\}$. Hence, the two antecedents are mutually exclusive, not because of exhaustification but rather because of the similarity ordering on worlds. This avoids the contradiction in (9).



(a) Similarity ordering, with w_3 most distant from the world of evaluation.

	phono	*sem*	*meeting a*	*meeting b*
w_1	T	F	T	F
w_2	F	T	T	F
w_3	T	T	F	T

(b) Truth conditions for example (8).

Figure 8 The Kratzer–Lewis account of conditionals avoids a contradiction for (8) via its use of a similarity ordering on worlds, as in (10).

5.3 Hurford's constraint

Arguments for the presence or absence of implicatures are challenging because of their sensitivity to a wide array of contextual factors. In addition, the readings of interest are often in entailment relations, making it difficult for people to give reliable judgments about their distinctness. For these reasons, the argument from Hurford's (1974) Constraint (HC) has played a central role in the literature. This

argument does not appeal to context or truth conditions directly, but rather only to lexical or constructional entailments and a general constraint on well-formed disjunctions.

Hurford expresses his generalization as follows:

> The joining of two sentences by *or* is unacceptable if one sentence entails the other; otherwise the use of *or* is acceptable.

The generalization is stated in terms of sentences, but Hurford's examples, given (11) with his original judgments, make it clear that he intends it to hold for sub-sentential disjuncts as well (he is likely assuming conjunction reduction):

(11) a. Ivan is an American or Russian.

b. The painting is of a man or a woman.

c. The value of x is greater than or equal to 6.

d. *John is an American or Californian.

e. *The painting is of a man or a bachelor.

f. *The value of x is greater than or not equal to 6.

Thus, we can specify the constraint as follows, presuming a generalized notion of entailment (Partee & Rooth 1983; MacCartney 2009).

Definition 9 (Hurford's constraint)**.** A sentence that contains a disjunctive phrase of the form X *or* X' is infelicitous if X entails X' or X' entails X.

Hurford observes that an apparent exception to the constraint needs to be made for examples involving scalar terms like *some or all*. He proposes that this reveals terms like *some* to be lexically ambiguous between versions with and without their upper bounds. CFS essentially endorse this by treating the relevant ambiguity as constructional, turning on whether or not the weak/general term is exhaustified locally or not (Gazdar 1979a,b; Singh 2008).

For this argument to have any force, we need to have a firm foundation of cases in which HC is in effect. It's a delicate situation because the cases of interest (the scalar ones) are prima facie counterexamples. The idea is that we get the most parsimonious account of the full range of data if we explain away such apparent counterexamples using local enrichment.

I claim that we have no such firm empirical foundation for HC. On the contrary, naturally occurring exceptions are extremely common. First, there is a common usage on which two contextually synonymous terms are given in a disjunction in order to provide a definition for one of them:

(12) a. She's a wine lover or oenophile.

b. She's an oenophile or wine lover.

This is a principled class of examples that we might set aside. Even if we do, though, there are numerous counterexamples involving proper entailment relations. I've collected and labeled 161 such examples to date at the following webpage:

(13) Counterexamples to Hurford's constraint: http://goo.gl/VAGqnB

The dataset includes 86 cases where the left disjunct entails the right, and 75 in which the right entails the left. I don't have a rigorous sampling procedure, so I am not sure we can probe this distribution for tendencies, but it does show that both directions are attested. What's more, for any two nouns N_1 and N_2 that one believes to be in a proper entailment relation, a Web search for "N_1 or N_2" will generally yield well-formed counterexamples.

Here is a small sample of the cases provided at the above link:

(14) a. Stop discrimination of an **applicant or person** due to their tattoos.

b. Promptly report any **accident or occurrence**.

c. The anchor will lie on the bottom and the **canoe or boat** will be held by the stream's current.

d. I believe that music can **change or affect** your emotions.

e. "As an **actor or performer**, you are always worried about what the next job's going to be," Hensley says.

f. Many state arbitration statutes contemplate motions to **correct or modify** being made to the tribunal directly.

g. James Clifford (1992, 1997) is the writer most associated with making the connection between culture and **travel or movement**.

h. Being a **captain or officer** is a privilege, and with that privilege comes great responsibility.

The examples seem to be motivated by a wide range of factors centering around the speaker's desire to highlight a subcategory. I conclude that HC does not exist and hence cannot furnish an argument for embedded implicatures.[11]

11 I do not consider here Singh's (2008) proposed extension of HC to cases involving semantically overlapping disjuncts. It's very hard to make the relevant judgments. If the sense of overlap is extensional, then even examples like *doctor or lawyer* will be counterexamples. If the sense of overlap is definitional, then it is extremely hard to figure out what criteria should be used to decide particular cases.

5.4 Intrusive constructions

CFS's argument is mainly based on intrusive implicatures: examples in which the implicature seems to be incorporated into the argument to a truth-functional operator in order to maintain consistency. Intrusive constructions like (15) are particularly clear instances of this pattern (Wilson 1975; Carston 1988; Levinson 2000; Recanati 2003; Horn 2006; King & Stanley 2006).

(15) It is better to eat *some* of the cake than it is to eat *all* of it.

Examples like this seem to erode the barriers between semantic and pragmatic content. The usual contention is that these are contradictory on their unenriched meanings, so it must be that the implicature has crept in to become part of the basic semantics. For example, Levinson (2000) says that such examples "on a purely semantic basis should be self-contradictory" (p. 200) and worries that they "should (on semantic grounds alone) be nonsensical" (p. 202).

Intrusion is not limited to comparatives (Levinson 2000; Horn 2006):

(16) a. Because he earns $40,000, he can't afford a house in Palo Alto.

b. If some of my friends come to the party, I'll be happy — but if all of them do, I'll be in trouble.

From the perspective of CFS, these examples are fully expected, and we might even expect them to be particularly robust: the *O* operator saves the sentences from being contradictory, so basic principles of charitable interpretation will steer listeners to the implicature-rich LF (CFS: §2.2).

The response from outside grammaticist views has been more varied. For Bach (1994) and Sperber & Wilson (1995, 2004), these examples do not involve implicatures, but rather elaborations of underspecified meanings, which assimilates these cases to things like (17) (Bach 1994; Horn 2006), in which I've put implicit material inside square brackets.

(17) a. Wood is strong enough [for this job].

b. Everybody [in the class] did the homework.

c. If Jack and Jill get married [to each other], then their parents will have to see each other again.

Geurts (2009) seems to accept that these might represent a limited class of counterexamples to the pure noncist position. In contrast, Russell (2006: §2) says that examples like (15) are not contradictory: phrases like *eat some/all the cake* are generics, with the *some* version crucially excluding situations in which all the cake was eaten, because these are not generic eat-some-cake situations.

So the exclusive behavior of the implicature is built into the meaning. In support of this view, Russell observes that the examples become marked if the predicates in question are not construed generically.

By and large, the examples are scalar, but manner cases are possible as well. The following are adapted from Levinson 2000: §3:

(18) a. It is safer to drive home and drink beer than it is to drink beer and drive home. (Wilson 1975)

b. It is better to eat your meat than to ingest it.

c. Ivan and Penny driving to Chicago is better than Ivan driving to Chicago and Penny driving to Chicago.

Example (18a) involves enriching *and* to 'and then'. This is normally treated as a manner implicature, derived from the presumption that the speaker will describe narrative events in temporal order. However, on Hirschberg's (1985) more general view of scalar implicatures as 'partial order implicatures', such examples can be assimilated to an *O* and *ALT* view. This strikes me as plausible for (18b) as well, and at least workable for (18c), given special semantic assumptions about collective coordinations like *Ivan and Penny*.

5.5 A case of local enrichment

Geurts & Pouscoulous (2009) present experimental evidence that the embedded implicatures predicted by theories like CFS are rarely available even in situations that would seem to favor them. Ippolito (2010) bolsters their case. Clifton & Dube (2010) argue that G&S's methods actually bias against embedded implicatures. And Sauerland (2010) takes the more measured position that embedded implicatures are real but that CFS do not predict a preference for them.

Unfortunately, reviewing this debate would take us too far afield,[12] so I focus on the later and lengthier follow-up by Chemla & Spector (2011). It offers the clearest experimental evidence I know of in favor of embedded implicatures. For the defender of Grice, the paper is daunting. The authors move systematically through a wide range of examples, offering innovative Gricean analyses and exposing the underlying logical structure of arguments for and against grammar-driven views. Finally, in their experiment 2, they home in on a class of sentences and associated scenarios that offer a chance to cleanly distinguish *Global* (Gricean) and *Local* (CFS-style) theories.

12 For additional details on these papers: http://stanford.edu/class/linguist236/implicature/materials/ling236-handout-04-23-embedded-experiments.pdf.

Fig. 9 summarizes the most relevant aspects of their experiment 2. The target sentence is in fig. 9(a). Its crucial property is that the scalar term *some of its circles* is in the non-monotonic semantic environment established by *exactly one letter*. As a result, the three readings of interest (fig. 9(b)) are such that the Local reading is logically distinct from the *Literal* reading and weaker than the Global reading (as indicated by the arrows). Thus, the Local reading cannot be derived via pragmatic strengthening of either of the others. If participants get the Local reading, we have good reason to infer that they are locally exhaustifying *some of its circles* to mean 'some but not all of its circles'.

Exactly one letter is connected with some of its circles.

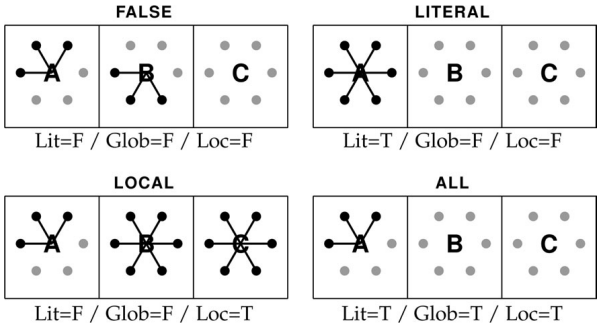
(a) Target sentence.

Global: one letter is connected with some but not all of its circles, the other letters are connected with no circle.

Literal: one letter is connected with some or all of its circles, the other letters are connected with no circle.

Local: one letter is connected with some but not all of its circles, the other letters may be connected with either none or all of their circles.

(b) Readings and entailment relations.



(c) Conditions.

Figure 9 A summary of Chemla & Spector's (2011) experiment 2. The target sentence was reliably judged an accurate description of the Local condition, strongly sugesting local pragmatic enrichment.

Participants judged the fig. 9(a) sentence in the four conditions given in fig. 9(c), assigning truth values on a continuous scale. The Local condition verifies only the Local reading, which, as I said above, cannot be derived as a pragmatic extrapolation of the other readings. Participants gave the sentence higher ratings on average in the Local condition than they did in the Literal condition (73% vs. 37%, a statistically significant difference). The results were similar for a sentence involving disjunction. See their figure 12 and appendix 3.2 for additional details. In short, the Local reading seems robustly available.

This looks like powerful evidence in favor of the theory presented in sec. 4. Skeptics of local enrichment might still have grounds to challenge it, though. For example, participants clearly struggled with the experimental items, often giving low ratings to true readings and sometimes giving high ratings to false ones. However, that just amounts to saying that it would be fruitful and informative to do more experiments in this experimentally challenging area. The bottom line for my purposes is that, for the reasons discussed in sec. 4.2, the theory is still a thoroughly pragmatic one that depends on the Gricean principles reviewed in sec. 2, so this win for CFS would not be a defeat for Grice.

6 Uncancelable implicatures

I argued in sec. 2.6 that implicature cancelation is not guaranteed. From the Gricean perspective, cancelation amounts to the speaker blocking an unwanted listener inference. From the grammar-driven perspective, it amounts to the speaker directing the listener away from an implicature-rich LF and towards another. In either case, other grammatical or contextual factors could prevent the speaker from doing this successfully.

So 'uncancelable implicature' is not an oxymoron, and a number of researchers have claimed sightings in the wild (Sadock 1978; Chierchia 2004; Eckardt 2007; Spector 2007; Magri 2009; Lauer 2013: §9). These have been interpreted as evidence for grammar-driven views. The argument is as follows. Grammar-driven views predict cancelation to be an option in nearly all cases (outside of those where the implicature is required to avoid other problems; see secs. 5.3–5.4). However, such theories have the flexibility to impose additional constraints on logical forms that would make certain *O* operators, and hence certain implicatures, effectively semantic commitments. For example, one could say that the *O* operator must modify a weak scalar term with specific morphological properties, or that it is required in the scope of specific quantifiers.

In contrast, proponents of grammar-driven views assume that Gricean accounts have no mechanism for ensuring that certain implicatures are obligatory. We have seen that this is not true, though. This judgment presupposes that

there is no synthesis between Gricean and grammar-driven views, when in fact, as I argued above, all theories tend to be amalgams of these two approaches already. In this case, nothing stops the Gricean from adopting the logical forms of grammar-driven views — special stipulations and all — and describing pragmatic reasoning with those more restrictive options.

Eckardt (2007) and Lauer (2013) take a more ambitious view, arguing that Grice already predicts uncancelable implicatures, without any need for special conditions on logical forms. Again, such explanations are compatible with grammar-driven views, and might even be welcomed for removing special stipulations. The cases easily within reach are those meeting description (19).

(19) *A recipe for obligatory implicatures*: there are forms φ and ψ such that, relative to the current context,

a. $[\![\varphi]\!] \sqsubseteq [\![\psi]\!]$, and phi

b. ψ is strictly more costly than $\not\psi$.

Magri (2009) explores a wide range of cases that meet this description. His primary examples are situations in which specific contextual assumptions result in two expressions being synonymous, as in (20), which is due to Spector 2007.

(20) *Contextual premise*: the atoms of the relevant molecule are inseparable.

a. # Some atoms went right.

b. The atoms went right.

Magri's intuition, shared by Spector (2007), is that (20a) sounds odd because it generates a scalar implicatures ('not all went right') that conflicts with the contextual premise. The theoretical assumption is that this would surprise the Gricean, who is (goes the story) doomed to predict that (20a) and (20b) cannot have differing pragmatic effects because, in context, they are synonymous.

We have seen, though, that the Gricean is alive to more than just distinctions in information conveyed. The theory is sensitive to linguistic differences. In the interactional model of sec. 3, this is captured by the cost function C, which is independent of informativity but has profound effects on the communicative behavior of the agents. For (20), we achieve the desired effect simply by assuming that 'some' is more marked in this context than 'the'. Fig. 10 presents this in the form of a communication game (def. 3). The semantic interpretation function (fig. 10(a)) encodes the assumption of contextual synonymy, and the cost function (fig. 10(b)) encodes the bias against using 'some'. With these assumptions in place, the initial speaker S_0 favors 'the', meaning that it will

always choose it (fig. 10(c)). From the listener's perspective, either message is fine (fig. 10(d)), but the speaker assumption means that the listener will encounter the 'some' variant only if the speaker is uncooperative or regards 'some' as semantically different from 'the'. No additional pragmatic reasoning can change this; the system is stable as given, because of the resetting (flattening of the probability values) that happens for the listener at each stage.

	'some'	'the'
p	⊤	⊤

(a) $[\![\cdot]\!]$

'some'	1
'the'	0

(b) C

	'some'	'the'
p	0.27	0.73

(c) S_0

	p
'some'	0.5
'the'	0.5

(d) $L(S_0)$

Figure 10 An account of (20). Where two forms are synonymous and one is more marked, the more marked one is infelicitous. A speaker who used the marked form would need semantic motivation, impossible with synonyms.

The same logic covers Magri's (2009) observations about the markedness of quantificational adverbs with individual-level predicates, as in #*often tall* (cf. *often happy*). On Magri's account, *often tall* is marked because it obligatorily generates an implicature that clashes with our background assumption that the extension of *tall* does not vary (in relevant ways) by time. On the present account, if we say these forms are denotationally equivalent and exploit the fact that *often tall* is strictly more costly than *tall*, the result looks like fig. 10.

I should add that I am not convinced that the facts are entirely as I have described them. There is always doubt surrounding the presence and stability of contextual assumptions like the one in (20). Even if we appear to have an explicit agreement, using a statement like (20a) would strongly convey that the speaker misunderstood the agreement or defected from it. The same is true for examples like *often tall*, since all individual-level predicates actually can vary across time. Nonetheless, in the unlikely event that contextual synonymy is guaranteed, message costs break the symmetry, leading to obligatory implicatures.

Eckardt (2007) and Lauer (2013) work through the case of disjunction in detail. In a disjunction $(p_1 \vee p_2)$, each p_i entails the whole disjunction, and the whole disjunction is almost certain to be strictly more costly than each of its disjuncts (outside of idioms that might appear less surprising and unusual than their parts). Thus, we have an instance of (19). In turn, the model delivers the

same dynamic as in fig. 10; we predict that S_0 will be heavily biased against using disjunction wherever a disjunct is true, as long as $C(p \vee q) > C(p) + C(q)$. In turn, direct cancelations like "p or q, in fact, p" are unlikely to be felicitous: the costs pile up with no communicative benefit.

However, following Lauer, I believe the disjunction case is more complicated. Because of the way disjunctions explicitly present alternatives, there is more room than in examples like (20) for the speaker to cancel the implicature with only mild uncooperatively as a price. For example, the speaker might *opt out* (in the sense of Grice 1975) of the maxim of quantity: "p or q, and I'm not telling which!". This makes the example less easy to capture directly with the simple model of sec. 3, so I refer to Lauer 2013: §9 for a more comprehensive one.

7 Conclusion

The debate between Griceans (of various stripes) and grammaticists (also a diverse bunch) has generated divisive rhetoric. I've argued that this air of conflict misrepresents the issues. The phenomena that have driven this debate — embedded implicatures and uncancelable implicatures — are capturable in both kinds of theory, leaving us with narrower questions about the phenomena. In any case, the contributions made by the two views are likely to be complementary; grammar-driven theories tell us where a speaker can put certain covert semantic operators, and interactional theories tell us what the speaker did, why he did it, and how the listener will construe his discourse move. While I grant that the tension between these two views has stimulated novel ideas and observations, I believe it would be more fruitful to proceed cooperatively from here.

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