2. An Opinionated Guide to Epistemic Modality

Kai von Fintel and Anthony S. Gillies

INTRODUCTION

Epistemic modals are interesting in part because their semantics is bound up both with our information about the world and with how that information changes as we share what we know. Given that epistemical modals are dependent in some way on the information available in the contexts in which they are used, it's not surprising that there is a minor but growing industry of work in semantics and the philosophy of language concerned with the precise nature of the context-dependency of epistemically modalized sentences. Take, for instance, an epistemic *might*-claim like

epistemic

(1) Jimbo might go to the party.

This sentence is true iff Jimbo's party-going is compatible with some (relevant) body of information. But that is where agreement ends. Whose information counts? Maybe it is just the knowledge of the speaker that is relevant. Maybe it is the knowledge of the speaker plus her conversational partners. Maybe it is information in some looser sense than *knowledge* that is relevant, or maybe epistemic modals require some more delicate way of aggregating that information. These strategies are all ways of exploring the extent to which epistemic modals are context-dependent. But maybe it isn't even information available in the context of utterance that is primarily relevant in the first place. That would make the

This is the paper formerly known as ''Epistemic Modality for Dummies''. The paper grew out of our presentations in an informational session at the annual meeting of the APA Eastern Division, 30 Dec. 2005. We would like to thank Frank Jackson and Timothy Williamson for their comments. We thank Josh Dever and the rest of the M&E reading group at the University of Texas at Austin, whose comments Josh relayed to us. We also thank Chris Potts and Timothy Sundell for comments.

truth-conditions of modals relative to bodies of information not provided by the context at all.[1]

In this paper, we will not directly contribute or even comment on that debate. Instead, we will present some of the background, linguistic and semantic, that we feel is necessary to be able to follow and contribute to ongoing work. We will also point to a number of open problems that the current upsurge in work has not yet attended to. We hope that a fuller picture of the properties of epistemic modals can help to broaden and deepen our understanding of this fascinating area.

This paper is structured as follows. After situating epistemic modals within the general setting of modality in natural language, we sketch the standard formal semantic approach to epistemic modality, which is a context-dependent possible worlds semantics. Then, we discuss two ways in which this semantics has to be refined or replaced: epistemic modals are evidential markers signaling the presence of an (indirect) inference or deduction and epistemically modalized sentences give rise to speech acts beyond just the assertion of the possible worlds proposition they express. We present two ways of approaching the second issue, one involving a bit of handwaving about multiple speech acts associated with one utterance and the other employing a dynamic semantic perspective on epistemic modals, which departs from the standard static semantics in interesting ways.[2]

1. MULTIPLICITY OF MODAL MEANINGS

Expressions of epistemic modality mark the necessity/possibility of an underlying proposition, traditionally called the PREJACENT,

[1] We have dubbed such "relativist" semantics *CIA theories* (von Fistel and Gillies, 2006) since in our general reformulation of them they propose that truth values are relative to contexts, indicies, and (points of) assessment. It is hard to keep up with the flood of papers on the topic. It started with MacFarlane (2003) and Egan et al. (2005). Then came Egan (2005), Yalcin (2005), Stephenson (2005), and Swanson (2005). More recently, work on the topic was presented at a conference at the Australian National University and many relevant papers are slated to appear in a volume on the topic, among them MacFarlane (2006). We have our own take on the issue: we criticize the relativist approach in our "CIA Leaks" (2006) and we ~~will~~ present an alternative view in our "*Might* Made Right" (in progress).

[2] For a more general overview of modality in natural language, epistemic and other, see ~~von Fintel and Gillies (2007)~~.

relative to some body of evidence/knowledge. The stock examples use the English modal auxiliary verbs *must* and *might*:

(2) a. There must have been a power outage overnight.
b. There might have been a power outage overnight.

Other relevant expressions include further modal auxiliaries such as *may, ought, should, can, could, have to, needn't* and adverbial expression such as *possibly, probably, certainly, apparently, supposedly, allegedly*.

Many of these expressions do not unambiguously express epistemic modality. In fact, many modals can express many different flavors of modality, depending on contextual factors. A spectacularly chameleonic modal is the English modal *have to*, as the following examples show (we use traditional labels to indicate the particular flavors of modality involved):

(3) a. *Given all those wet umbrellas*, it **has to** be raining. [epistemic]
b. *According to the hospital regulations*, visitors **have to** leave by six pm. [deontic]
c. *According to my wishes as your father*, you **have to** go to bed in ten minutes. [bouletic]
d. Excuse me. *Given the current state of my nose*, I **have to** sneeze. [circumstantial]
e. *Given the choices of modes of transportation and their speeds*, to get home in time, you **have to** take a taxi. [teleological]

The variability continues even within a given type of meaning, as the following examples of different epistemic uses of *might* demonstrate:

(4) a. *As far as Bill knows*, John **might** be the thief.
b. *Given what we knew at the time*, John **might** have been the thief.
c. *Given the results of the DNA tests*, John **might** be the thief. But *if we take the eyewitness seriously*, John **can't** have been the thief.

When we encounter an unmodified modal on its own, as in (5), the context will have to help disambiguate:

(5) John has to be in New York.

(5) could be an epistemic claim or a deontic claim. If epistemic, it might be based on just the speaker's evidence or all available evidence or . . .

In sum, simple modal expressions (like *can*, *might*, *must*, *have to*) have a multitude of uses: different flavors of modality (epistemic, deontic, . . .) and different subflavors (what Bill knows, what we knew, what the DNA tests reveal).

Given this systematic multiplicity of meanings, a successful semantic analysis cannot simply divide and conquer, say by developing an analysis of deontic *ought* that shows no connection to a separate analysis of epistemic *ought*. Instead, we should combine a shared semantic core with mechanisms for modulating the core meaning in context.

2. A CONTEXT-DEPENDENT POSSIBLE WORLDS SEMANTICS

The semantics for modals proposed by Kratzer (1977, 1978, 1981, 1991), based on the seminal work by Kripke (1963), Hintikka (1962), and Copeland (2002), is designed to fulfill the two desiderata we just identified (a common semantic core supplemented by mechanisms for contextual modulation). The basic idea is that modals are quantifiers over possible worlds. Just what possible worlds a particular occurrence of a modal quantifies over is determined explicitly by restrictor phrases (*according to*, *given*, *based on*, etc.) or implicitly by the context. Kratzer proposed to make the interpretation of a modal relative to a contextual parameter, which she called the CONVERSATIONAL BACKGROUND.[3] Instead of saying that the parameter is of the type of an accessibility relation (a relation between worlds), she proposed that conversational backgrounds are functions from evaluation worlds to sets of propositions. Some example values for the parameter are *what is known*, which would map any world into

FN:3

[3] Kratzer actually made the interpretation relative to *two* conversational backgrounds: the MODAL BASE, which provides the set of accessible worlds, and the ORDERING SOURCE, which induces an ordering on the worlds provided by the modal base. The complications ensuing from using an ordering are mostly irrelevant to our purposes here, although for a fuller treatment of epistemic modality and in particular for an understanding of weak necessity modals like *ought* and *should*, one would have to include the ordering in the semantics.

the set of propositions known in that world, or *what the hospital regulations require*, which would map any world into the propositions that need to be true according to the hospital regulations in that world.

For concreteness, we will assume that sentences with modals in them have a logical form that includes a silent ''pronominal'' of the type of a conversational background, whose value is determined by the context (just as the value of a free pronoun like *she* is determined by the context), possibly with the aid of restricting expressions (*judging by the DNA evidence, according to your father's wishes, in view of what the eyewitness told us, . . .*):

(6) *might* (B) (ϕ)

might (B) (ϕ) is true in w iff ϕ is true in *some* world that is B-accessible from w

B: the *conversational background* (Kratzer), a function from worlds to sets of propositions, or simpler to sets of worlds (i.e. an accessibility function of sorts)
ϕ: the prejacent proposition

The lexical entry for *must* would be analogous, treating it as a universal quantifier instead of as an existential quantifier like *might*.

Kratzer also proposes that *if*-clauses should be seen as restrictors of the contextual argument of the modal. In other words, *if*-clauses are used to temporarily (hypothetically) restrict attention to a subset of the B-accessible worlds. Consider a ''conditional'' sentence such as (7).

(7) If John is not in his office, he might be in the cafe.

In Kratzer's proposal, what happens is that the proposition that John is not in his office is (temporarily, hypothetically) added to the body of evidence that the modal *might* is sensitive to. The modal then claims that there are some worlds compatible with that body of evidence and with the proposition that John is not in the office in which he is in the cafe.

We will not really deal with conditionals in this paper, but would like to point out that based on Kratzer's proposal, any progress in the analysis of modals, epistemic or otherwise, will also contribute to the analysis of conditionals, since according to this story, *if*-clauses are simply devices to further modulate modal claims.

It should be noted that not all modals show maximal flexibility as to what kind of conversational background they tolerate. For example:

FN:4

- English *might* doesn't have deontic uses;[4]
- German *sollen* can only be based on hearsay evidence;
- etc.

These idiosyncrasies can be modeled as selectional restrictions on the kind of conversational background a modal is willing to combine with. A related issue that, as we mentioned in the introduction, has received a lot attention recently is what bodies of evidence epistemic modals can be sensitive to. One might have expected that there is considerable contextual variability, ranging from solipsistic readings (*what the speaker knows*) to community-based readings (*what we know*) all the way to even more objective readings (*what the available evidence would indicate if anybody bothered to evaluate it*). Whether that is in fact what we find and whether we need new semantic mechanisms to deal with the facts about epistemic modals is the subject of an ongoing dispute, in which we will not engage here.[5]

FN:5

We will now turn to two aspects in which the semantics we have sketched here is not quite adequate (yet).

3. EVIDENTIALITY

Imagine that we are seeing people coming into the building carrying wet umbrellas. It would be perfectly reasonable to say *It must be raining*. Our semantics as sketched above would support such a claim: in all of the worlds compatible with the available evidence (wet umbrellas, the absence of any other good explanation for the

[4] Tim Sundell (pc) points out to us that this is strictly speaking not obviously true. Consider examples such as the following:

(i) You might send your grandmother a thank you note for the present. After all, she cashed in her 401K to buy it for you.

While *might* here doesn't have the expected permission sense, it does seem to traffic in something like deontic advice rather than epistemic possibility. We leave the proper treatment of this use of *might* to someone else for now.

[5] See n. 1 for references to work in this debate.

wet umbrellas, . . .), it is raining. But now imagine that we look out the window and see the pouring rain. In that case, it would be exceedingly strange to say *It must be raining*. In fact, what one should say in this scenario is the non-modalized sentence *It is raining*. Why would that be? Surely, in all of the worlds compatible with the available evidence (the fact that it is pouring outside, the absence of any indication that we are being deceived, . . .), it is raining. So, the truth-conditions of the modal sentence appear to be satisfied.

Karttunen (1972) was one of the first authors to claim that such examples make it seem that an epistemic necessity modal actually makes a weaker claim than the corresponding non-modalized sentence, something not predicted by the standard possible worlds semantics. He considers the following pair of examples:

(8) a. John must have left.
b. John has left.

He writes:

> Intuitively, (8a) makes a weaker claim than (8b). In general, one would use the epistemic *must* only in circumstances where it is not yet an established fact that John has left. In stating (8a), the speaker indicates that he has no first-hand evidence about John's departure, and neither has it been reported to him by trustworthy sources. Instead, (8a) seems to say that the truth of *John has left* in some way logically follows from other facts the speaker knows and some reasonable assumptions that he is willing to entertain. A man who has actually seen John leave or has read about it in the newspaper would not ordinarily assert (8a), since he is in the position to make the stronger claim in (8b) (1972: 12).

We have to dispute the claim that *must*-claims are weaker than unmodalized claims. Here is an example of an appropriate use of *must* in a case of a logical inference from given premises:

(9) The ball is in A or in B or in C.
It is not in A. It is not in B.
So, it must be in C.

There is clearly no sense at all of weakness in the conclusion in (9). What we would like to suggest is that epistemic modals signal the presence of an indirect inference or deduction rather than of a direct observation. This is independent of the strength of the claim being made.

Our proposal was in fact anticipated by Frege:

> What distinguishes the apodeictic from the assertoric judgment is that it indicates the existence of general judgments from which the proposition may be inferred—an indication that is absent in the assertoric judgment. (1879: 5)

In fact, Karttunen also cites this passage from Frege and continues

> so, the role of *must* in (8a) is to indicate that the complement proposition is inferred but not yet known to be true independently. The intuitive feeling that (8b) is a weaker assertion than (8b) is apparently based on some general conversational principle by which indirect knowledge—that is, knowledge based on logical inference—is valued less highly than 'direct' knowledge that involves no reasoning. (Karttunen, 1972: 13).

Our claim that epistemic modals signal the presence of an indirect inference or deduction rather than of a direct observation amounts to claiming that epistemic modals incorporate a kind of EVIDENTIAL meaning component. Evidential markers are expressions found in many languages that signal the source of evidence a speaker has for the prejacent claim. Evidentials often come in a system of related meanings. Figure 2.1 is a reproduction of Willet's (1988) taxonomy of evidentials. It appears that seen as evidentials, epistemic modals are markers of INDIRECT INFERENCE, that is the rightmost branch of Willet's system.[6] It should be noted that the literature on evidentials

FN:6

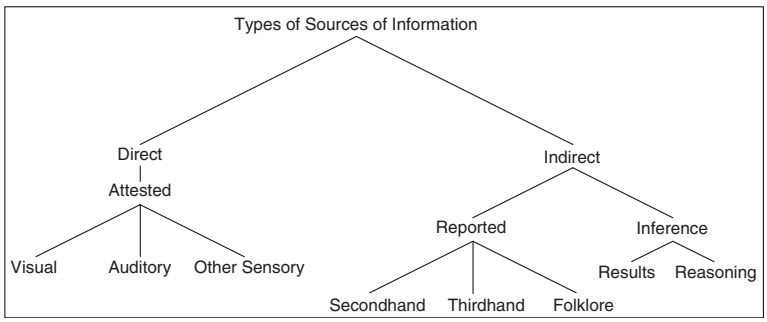

Figure 2.1. Willet's taxonomy of evidentials

[6] Note that epistemic modals do not cover the notion of indirect evidence derived from reports (the sister of indirect inference in Willet's system). Frank Jackson (pc) gave us a relevant scenario. When one reads in a book that the Battle of Hastings was

often makes a strict distinction between epistemic modality and evidentiality, but the facts we have discussed here indicate that this is too simplistic a position.[7]

FN:7

It is an open problem how exactly to capture the evidential flavor of epistemic modals in the kind of possible worlds semantics we have assumed so far. There is a proposal by Kratzer (1991) according to which epistemic modals don't simply range over the worlds compatible with what is known; she suggests that in addition, they are sensitive to other less reliable sources of information. This again is meant to capture the apparent weakness of epistemic modals. We do not deny that one *can* use *must* in situations where one is drawing on assumptions that do not attain the status of confident knowledge. But when it comes to signaling weakness of an inference, it is often much more appropriate to use expressions like *ought* or *should*.[8] As we showed above, *must* is not an automatic carrier of a signal of weakness. In the absence of any other concrete proposal, we will leave the problem unresolved and hope that future research will find a solution.[9]

FN:8

FN:9

4. EPISTEMIC MODALITY IN THE SECOND DIMENSION

So far, we have assumed that modalized sentences express complex propositions with a possible worlds-based quantificational meaning

fought in 1066, one's evidence is indirect; one does not observe the battle or anything like that. But it would be wrong to say 'The Battle of Hastings must have been fought in 1066'.

[7] See also Blain and Déchaine (2005) and Matthewson *et al*. (2006) for cross-linguistic evidence for the close connection between epistemic modality and evidentiality. 2007

[8] The compositional semantics of weak necessity modals like *ought* and *should* is explored by von Fintel and Iatridou (2006).

[9] Another proposal for handling Karttunen's problem appears in Veltman (1985). The basic idea is to assign truth-values based on an underying system of ''states'', where: (i) those states might be partial, not always determining the truth/falsity of the basic sentences; and (ii) the states are ordered by whether one state can ''grow'' into another. Then *must* says, at a state, that its prejacent is true in every state that can be gotten to from there. So, in general, *must* ϕ will not entail ϕ since the present state might not decide the fate of ϕ even though it is true at all the successor states. We are not sure whether this in fact solves the problem as we have characterized it, which is not so much a problem of unexpected weakness but a problem of finding the semantic source of the signal of indirect inference. We'll leave this to another occasion or other researchers.

built on top of a prejacent unmodalized proposition. While this is indeed the standard analysis in formal natural language semantics, it is not actually the standard assumption in descriptive and typological linguistics.

The most common analysis in descriptive work treats modality as an expression of the speaker's attitude towards the prejacent proposition, rather than giving rise to a complex proposition with its own distinct content. The prevalence of this conception can perhaps be traced back to the influence of Kant, who wrote in the *Critique of Pure Reason* that ''the modality of judgments is a very special function thereof, which has the distinguishing feature that it does not contribute to the content of the judgment'' (1781: 74). This idea seems to have influenced both practicing linguists and a subset of logicians, including Frege, who wrote in the *Begriffsschrift* that ''[b]y saying that a proposition is necessary I give a hint about the grounds for my judgment. But, since this does not affect the conceptual content of the judgment, the form of the apodictic judgment has no significance for us'' (1879: 5).

Some prima-facie evidence that the speaker's comment analysis is not entirely crazy comes from considering exchanges like the one in (10):

(10) Q: Why isn't Louise coming to our meetings these days?
A: She might/must be too busy with her dissertation.

(We note that dialogues like this one are used by Simons in her recent work on parentheticals (2006). Here, we adapt her paradigm to the case of epistemic modals.) The crucial point is that what is proposed as the reason for Louise's absence is that she is too busy with her dissertation, not that it might or must be the case that she is too busy with her dissertation. In other words, the response in (10) offers the prejacent as the answer to the question and the epistemic modals seem to signal something like the speaker's assessment of the likelihood that this is the right answer.

If one wants to take this as evidence that modals do not contribute to the truth-conditional content of the sentence, one needs to develop an alternative semantics for them. Two possibilities are of particular interest. (i) Epistemic modals might be treated as ''parentheticals'', phrases that give side-remarks in a separate semantic dimension from the normal truth-conditional content. The recent treatment of such parentheticals by Potts (2005) might be thought

to be adaptable to the analysis of epistemic modals. (ii) Epistemic modals might be treated as ''speech act modifiers''. While presenting an unmodalized sentence is interpreted as a straightforward assertion, adding an epistemic modal might indicate that a different kind of speech act (albeit with the same truth-conditional content) is performed. One might for example say that a sentence like *There might have been a mistake* expresses the speech act ''I (hereby) advise you not to overlook the possibility that there has been a mistake'' (cf. Eric Swanson's work in progress (2005)).

In either implementation, the speaker's comment analysis faces serious problems, most importantly the fact that epistemic modals can be embedded in yet more complex constructions. Consider for example the following sentence:

(11) If there might have been a mistake, the editor will have to reread the manuscript.
   a. $\neq$ If there has been a mistake, as is possible, the editor will have to reread the manuscript.
   b. $\neq$ If I advise you not to overlook the possibility that there has been a mistake, the editor will have to reread the manuscript.

As we can see, the attempted paraphrases in (11a) and (11b) do not come anywhere near what (11) means. It should be obvious that what the modalized sentence (*there might have been a mistake*) contributes to the truth-conditions of the entire complex is precisely the truth-conditions we had assumed it expresses: if the evidence is compatible with there having been a mistake, the editor will have to reread the manuscript.

There are many other cases in which an epistemic modal embeds felicitously and where it contributes modalized truth-conditions:[10]

FN:10

[10] This is not to say that epistemic modals embed completely freely. For example, when we try to combine a deontic modal with an epistemic modal, we can do so in one way:

(i) It's midnight. These kids must be allowed to stay up really late. [epistemic over deontic]

But the other way (which would embed an epistemic modal under a deontic modal) is not possible:

(ii) They ought to have to be home. [Not: deontic over epistemic]

(ii) has no reading where it would say that there is an obligation for it to follow from the evidence that they are home.

(12) There can't have been a mistake. [Negation over modal]
(13) Bill thinks that there might have been a mistake. [Attitude predicate over modal]
(14) Where might you have put the keys? [Question over modal]
(15) The keys might have been in the drawer. [Past over modal]
(16) The editor reread the manuscript because there might have been a mistake. [Causal operator over modal][11]
FN:11
(17) The detective interviewed every resident who (based on the time of the accident) might have seen the accident. [Quantifier over modal]

So, we find it unlikely that the speaker's comment analysis is correct in either of the two forms we have considered above, since they would not allow the contribution of epistemic modals to have compositional effects in embedded positions. We will look at two other possibilities. One is a semantically conservative proposal, according to which epistemic modals have exactly the kind of possible worlds semantics we have been assuming but sentences with epistemic modals are used to perform more than the speech act of asserting that possible worlds proposition. The other approach is to reconsider the entire semantic set-up and move to a more dynamic picture already at the semantic level.

5. MULTIPLE SPEECH ACTS?

In this section, we propose a conservative addition to the possible worlds semantics for epistemic modals. Our proposal is inspired

Another case that has received some attention is that epistemic modals seem to serve as some kind of barrier for quantifier raising, see von Fintel and Iatridou (2003).

We have nothing further to say here about why epistemic modals show these effects. The crucial point we're trying to make is that they *can* sometimes be embedded in complex constructions, not that they always can.

[11] Frank Jackson (pc) doubts that this is really a causal operator over a modal; rather, he would argue that this example involves a causal operator over a belief in an epistemic possibility. That is, (16) is best thought of as:

(i) The editor reread the manuscript because she believed there might have been a mistake.

That would be just fine with us, because it shows the epistemic modal embedded twice over.

by a similar proposal by Simons on other kinds of parentheticals (2006). Consider:

(18) Q: Why isn't Louise coming to our meetings these days?
A: I heard she is too busy with her dissertation.

Simons suggests that the answer in (18) achieves two simultaneous speech acts: an assertion that I heard that she is too busy with her dissertation *and* offering her dissertation work as an explanation of her absence. Crucially, while the second speech act is the *main point* of the utterance, the truth-conditional content of the assertive speech act is such that the putative ''parenthetical'' *I heard . . .* does in fact contribute to the truth-conditions of the sentence it occurs in.

We would like to say that epistemic modalized sentences similarly are used to effect two speech acts. Consider again:

(19) There might have been a mistake (in the calculation).

Our suggestion is that a sentence like (19) is used to make two speech acts: an assertion (?)[12] that it is compatible with the evidence that there has been a mistake, *and* proffering (with an explicit lack of conviction) that there has been a mistake *or* giving advice not to overlook the possibility that there has been a mistake.[13]

This picture would explain two properties of epistemically modalized sentences that create a conflict for the two-dimensional proposals we discussed in the previous section: (i) the main point of an epistemically modalized sentence often seems to be centered around the truth of the prejacent, while (ii) epistemically modalized sentences can be rather freely embedded and then seem to contribute the standard possible worlds meaning of epistemic possibility/necessity. The multiple speech acts analysis says that unembedded uses of epistemically modalized sentences are used to effect two speech acts, one of which is the putting forward of the prejacent, thus accounting for property (i); in embedded occurrences,

[12] Whether the speech act is really one of assertion proper is something that might have to be rethought. If the claim made by epistemic modals is relative to not just the speaker's evidence but to some more objective or communal body of evidence, then the speaker may not be in a position to really assert anything about that evidence, especially if we assume strong norms of assertion such as the knowledge-based norms defended by some. We will leave this question open here.

[13] We readily admit that one would have to sharpen the characterization of the proposed second speech act. After all, whenever one asserts ϕ, one would appear to be giving advice not to overlook the possibility that ϕ. What precisely is special about epistemic modals then? (Thanks to the Austin reading group for raising this issue.)

the epistemically modalized sentence is not used to (directly) effect a speech act at all and all it does is contribute its truth-conditional content, thus accounting for property (ii).[14]

FN:14

Since there are two speech acts, one of which has as its content the modalized proposition and the other of which has as its content the prejacent, it is not too surprising to find evidence that both propositions can be at play in complex dialogues. Pascal and Mordecai are playing Mastermind. After some rounds where Mordecai gives Pascal hints about the solution, Pascal says

(20) There might be two reds.

Mordecai, knowing the solution, has a range of possible responses:

(21) a. That's right. There might be.
b. That's right. There are.
c. That's wrong. There can't be.
d. That's wrong. There aren't.

Clearly, Mordecai's response can target *either* the epistemic claim or the prejacent proposition. The possibility that in dialogue, the truth-conditions of the prejacent are saliently at issue should therefore not be taken as evidence that epistemic modals do not contribute to the truth-conditions of the sentence they occur in. (One should also not take such data as evidence that a non-standard semantics for the modal is needed.)

We would recommend that fans of a static possible worlds semantics explore the prospects for the multiple speech act pragmatics we have sketched here. Pursuing this line means taking seriously the idea that epistemic modals are not, properly speaking, things that go in for assertion. Another way to go, though, is to say that it's all assertion, but that the effect of assertion is a bit more delicate than on the Stalnaker picture. And one way of cashing that out is to model those (dynamic) effects in the semantics proper. Pursuing this line means redrawing the border between semantics and pragmatics, capturing (some of) the effects successful assertions have on the context in the semantics proper. This is the place to move to an exposition of the dynamic semantic approach to epistemic modals, which is what the remaining sections of the paper are concerned with.

[14] Thanks to the Austin reading group for pressing us on the point discussed in this paragraph.

6. TWO SOURCES OF INSPIRATION FOR A DYNAMIC PERSPECTIVE

Two morals have emerged thus far. First, modals—and so epistemic modals—are context sensitive: they act as quantifiers over sets of worlds, just which sets being a function of context. And we have seen that there is good reason to explore the idea that epistemic modals involve a kind of non-propositional comment on their prejacents. (We'll set aside the problem of the evidential signal carried by epistemic modals.) One lesson to draw from this pair of morals is that understanding the interpretation of epistemic modals may well force us to rethink the division of labor between the semantics of these constructions and their pragmatics. We now turn to sketching a dynamic semantics for epistemic modals that does just that by assimilating some of the pragmatic effects of utterances into the semantic values assigned to them.[15]

FN:15

Our goal here is not to present the most sophisticated or most comprehensive treatment of epistemic modals in a dynamic semantics. We intend to leave a lot of interesting questions unasked and unanswered. Instead, what we want to do is to motivate thinking about epistemic modals from a dynamic perspective, give some background for the uninitiated, and show how the framework—even in the most toyish scenarios—can be fruitful for exploring how our pair of morals impinges on the semantics for modals.

The kind of dynamic framework we sketch below draws inspiration from two sources: classic theories of the interplay between context and assertion, and the semantics of formal programming languages.

Begin with the familiar picture of assertion (Karttunen, 1974; Lewis, 1979; Stalnaker, 1978): An (assertive) utterance of a sentence ϕ in a well-run conversation takes place against a background context, the set of worlds compatible with what has been established up to that point. The proposition expressed by the speaker's utterance of ϕ is constrained by the context. And, finally, that proposition is

[15] We have drawn freely on some classic references (Groenendijk and Stokhof, 1991; Heim, 1982; Kamp, 1981; Veltman, 1996).

added to the context, changing it by reducing the uncertainty in it a bit.

Dynamic semantics takes this picture and pushes it further, focusing on the relation between the context prior to the utterance and the context posterior to the utterance. We thus swap the aim of trying to identify the CONTENT of bits of natural language—what proposition an utterance of them expresses—for the aim of trying to identify the CONTEXT CHANGE POTENTIAL of those bits—how utterances of them affect contexts.[16]

FN:16

Similarly for the case of the semantics of programs. Begin with a simple propositional language and add to it the ability to represent actions such as **if** ϕ **then** α **else** β. To the stock of atomic sentences and boolean connectives we add a stock of atomic PROGRAMS and suitable program operators (sequencing, choice, test, and so on). We can then interpret such a language in a pretty simple extension of the standard possible worlds semantics for propositional modal logic (Harel *et al.*, 2000). It is clear enough what declarative sentences of such a language mean: their interpretations are just the set of states at which they are true. Programs, on the other hand, express *relations* between states: a pair $\langle u, v\rangle$ is in the interpretation of a program π just in case executing π in state u (possibly) terminates in state v. The intuition is that programs express their input-output relations. So the complex program **if** ϕ **then** α **else** β has as its denotation the set of pairs of states $\langle u, v\rangle$ such that either ϕ is true at u and v results from executing the program α in u or ϕ is not true at u and v results from executing the program β at u.

Dynamic semantics takes this picture and pushes it further, treating *all* sentences as programs for changing the context. They are instructions for updating it. Thus the semantic values of sentences are of the same kind associated with programs: relations between states (i.e. contexts), or, as they are more familiarly known, CONTEXT CHANGE POTENTIALS (CCPS).

So much for inspiration. We next sketch a pseudo-dynamic semantics for a simple propositional language and say in just

[16] There need not be anything sacrosanct about the context to be updated being identified with the common ground. It could be the hearer's information state, or what she takes the common ground to be, or what she takes the speaker to take the common ground to be. At the most abstract level, the issue is about how a body of information responds to the information a sentence carries.

what sense it is not quite dynamic. We then make it truly dynamic by adding epistemic modals into the mix. Finally we show how, even in this simple system, the dynamic perspective has something interesting to say about our two guiding morals.

7. ALMOST DYNAMIC SEMANTICS

Let's keep things simple. Suppose we have a small fragment of natural language that uses propositional logic—the closure of a set of atomic sentences under negation ($\neg$) and conjunction ($\wedge$)—as an intermediate language: expressions of natural language are mapped (via an isomorphism) to expressions of this intermediate formal language, which are then mapped (via homomorphism) to semantic values.[17] Since the semantics will treat sentences as programs for changing contexts, we need to settle on what kind of information is represented in those contexts. Our intermediate language is expressively pretty poor, so the chunks of information our semantics will traffic in will be pretty coarse: for now we will assume that it is the hearer's information about the world that undergoes change when she interprets bits of natural language, representing the information she has by the set of worlds compatible with it. Such information states—really not anything other than conversational backgrounds—will be our contexts.

Let us take worlds to be functions from atomic sentences to truth-values, information states to be sets of worlds, and the set of information states to be the powerset of the set W of worlds.[18] That leaves us with two special cases of information states. The MINIMAL information state is W itself, the state in which no world has yet been ruled out. At the other end of the spectrum lies the ABSURD information state $\emptyset$—we want to stay out of that one since it represents a broken context.

[17] This is the so-called ''indirect method'' of interpretation familiar from Montague's PTQ.

[18] Since the information we are trafficking in is coarse, we assume that worlds decide the truth-values of the atoms of our language and that two worlds are distinguishable just in case they differ over some atom. So, for our purposes here, we will assume that worlds are simply functions from atoms to truth-values. Nothing important is lost if we further assume that the set of atoms for our propositional language is finite, thus keeping the space of worlds finite.

The motivating intuition is that sentences express programs for changing information states, and so should have as denotations relations between information states. So, for example, interpreting an atom ϕ should take us to posterior states which have only the ϕ-worlds from the prior state in them. Thus $\langle s, s' \rangle$ should be in the interpretation assigned to ϕ just in case s' is just like s except we throw out the worlds in which ϕ is false. That would match the motivating idea pretty well: ϕ is a program for eliminating falsifying worlds from consideration.

We could proceed in this way giving the CCPs as relations between states, and certainly some proposals in dynamic semantics do (see, e.g. Beaver, 2001; Groenendijk and Stokhof, 1991). But with just a bit of sleight of hand we can express these relations between states as functions on the set of states, making things a little more manageable. So that is what we will do.

Here is a simple assignment of CCPs to sentences of our intermediate language as update-profiles. Where ϕ is some formula of our intermediate language, $[\![\phi]\!]^{\text{ccp}}$ denotes the function on information states that is ϕ's meaning.[19] Thus, given a context s as argument, $[\![\phi]\!]$ takes us to the posterior state we might write (using prefix notation for our function) $[\![\phi]\!](s)$. We instead follow the convention in dynamic semantics and write the functions using postfix notation:

(22) PSEUDO-DYNAMIC UPDATE SEMANTICS
- (a) $s[\![p]\!] = \{w \in s : w(p) = 1\}$,
- (b) $s[\![\neg\phi]\!] = s \setminus s[\![\phi]\!]$,
- (c) $s[\![\phi \wedge \psi]\!] = s[\![\phi]\!][\![\psi]\!]$.

The atomic case is straightforward enough. Negation is set-subtraction: first figure the update induced on the input state by the embedded sentence; any world surviving this update is eliminated from the input state. And conjunction is functional composition, the output state to interpreting the first conjunct is the input for interpreting the second.

But assigning interpretations is only part of the job a semantic theory has to do. We also want it to predict entailments, patterns

[19] When there is no risk of confusing $[\![\cdot]\!]^{\text{ccp}}$ for the (static) context-invariant interpretation function $[\![\cdot]\!]^{\text{classic}}$ over our fragment, we will conserve the ink and omit the superscript.

of consistency, and the like. And for that we need to be able to say when a sentence is true—that is, true with respect to an information state. Once we take the plunge into the dynamic framework, there are—purely formally speaking—a number of entailment relations one might opt for.[20] We adopt a simple perspective, based on two simple intuitions:

(23) a. A sentence is true in a state iff the information it carries is already present in that state.
b. A sequence of sentences entail another sentence if adding the information of that sequence to any state yields a state in which the sentence is true.

The formal implementation of these is, in turn:

(24) a. ϕ is true in s, $s \models \phi$, iff $s[\![\phi]\!] = s$.
b. $\phi_1, \ldots, \phi_n$ entail ψ, $\phi_1, \ldots, \phi_n \models \psi$, iff for any s: $s[\![\phi_1]\!] \ldots [\![\phi_n]\!] \models \psi$.

Thus truth is a matter of seeing whether the relevant information state is a fixed-point of the CCP of the relevant sentence, and entailment is the natural generalization of this: to see if an entailment holds we add up the CCPs of the putative entailers and see if the putative entailee is true in the resulting context.[21]

8. THE LACK OF REAL DYNAMICS SO FAR

Sadly, we do not yet have anything particularly ''dynamic'' here. We began by noting that one inspiration for dynamic semantics is a picture of assertion whereby contexts evolve as conversations proceed by adding to them the contents of the sentences asserted. Perhaps all we have done so far is foster confusion by complicating this original—and rather pleasingly elegant—picture. But there is a point to our fostering. We will show, precisely, in what sense our update semantics for our toy fragment is not at all dynamic, thereby saying what we need to get some real dynamics. Adding epistemic

[20] See, e.g. van Benthem (1996) for a discussion of some of the menu of options.

[21] Two small notes: (i) we have opted for an ''update-to-test'' flavor of entailment; (ii) since in a dynamic set-up order of updates may well matter to what state we land in, and entailment is defined in terms of a sequence of updates, order may well matter to entailment as well.

modals on top of the system as it now stands will turn out to do the trick. From confusion comes enlightenment.

Whenever we have a space of information states (contexts), we can in general ask what it means to say that one state contains at least as much information as another. This may well impose some structure on the space of states, and often enough that structure is pretty well-behaved in that the relation *at least as much information as* partially orders the space of contexts and is such that every pair of contexts has a *join*—that is, if c and c' are two contexts, then there is a least informative context c'' that contains at least as much information as c and at least as much information as c'.[22] Now, an update function just amounts to a complicated way of doing something that should be simple if the following holds:

FN:22

(25) Updating a context c with ϕ is the same as taking the join of c and the update of the *minimal* state with ϕ.

In that case, the context c is not contributing anything special to the interpretation, and CCPs can be replaced by intersecting classical propositions. That turns out to be exactly what is going on in our simple semantics.

Let's walk through why. We have a space of contexts (information states)—the set of subsets of W, call it I. Since an information state is just a set of worlds, one state contains at least as much information as another just in case the first is a subset of the second. It is easy to check that set intersection is a join operation for this space of states (remember that W is the minimal state): $s' \cap s = s'$ iff $s' \subseteq s$. Now, the claim is that our update function above offers nothing really new if the following holds:

(26) For any state s and formula ϕ: $s[\![\phi]\!] = s \cap W[\![\phi]\!]$.

And a simple inductive proof shows that (26) does hold. In fact, $W[\![\phi]\!]^{\text{ccp}}$ is just the (static) context-invariant propositional content $[\![\phi]\!]^{\text{classic}}$—the set of ϕ-worlds.

Given this reduction of our CCPs to mere adding of propositional contents, it is no surprise that our dynamified versions of truth and entailment similarly reduce. (26) straightaway entails that

[22] Equivalently: let $\circ$ be a binary operator over the space of contexts $\mathcal{C}$ with minimal element 0. The operator $\circ$ is a join iff it commutes, associates, and is such that for any context c: (i) $c \circ 0 = c$ and (ii) $c \circ c = c$. It then induces an order over $\mathcal{C}$: if $c \circ c' = c'$ then c' contains at least as much information as c does.

(27) a. $s \models \phi$ iff $s \subseteq [\![\phi]\!]^{\text{classic}}$.
b. $\phi_1, \ldots, \phi_n \models \psi$ iff, for any s: $s \cap [\![\phi_1]\!]^{\text{classic}} \cap \ldots \cap [\![\phi_n]\!]^{\text{classic}} \subseteq [\![\psi]\!]^{\text{classic}}$.

Consider (27a). Our definition has it that $s \models \phi$ iff $s[\![\phi]\!]^{\text{ccp}} = s$. But by (26), $s[\![\phi]\!]^{\text{ccp}} = s \cap W[\![\phi]\!]^{\text{ccp}} = s \cap [\![\phi]\!]^{\text{classic}}$. Thus we have that $s \models \phi$ iff $s \cap [\![\phi]\!]^{\text{classic}} = s$. But the latter is true iff $s \subseteq [\![\phi]\!]^{\text{classic}}$. A similar argument works for (27b).

The possibility of this kind of reduction of these CCPs follows from a general result: we can reduce a function on sets in this way exactly when that function is ELIMINATIVE and DISTRIBUTIVE.[23] For our CCPs these generic properties are the following:

FN:23

(28) a. (ELIMINATIVITY) $s[\![\phi]\!] \subseteq s$.
b. (DISTRIBUTIVITY) $s[\![\phi]\!] = \bigcup_{w \in s} \{w\}[\![\phi]\!]$.

Eliminativity just says that contexts change by shrinking uncertainty—no backtracking or information loss allowed. And distributivity is the requirement that computing the changes to a state induced by a sentence can just as well be got by taking the worlds in that state one at a time, figuring the changes induced by the sentence to those singletons, and collecting up the results at the end. Distributive functions thus only care about very local matters of fact since the sets they operate on can be replaced with singletons of the elements that make up those sets. Our update function satisfies both constraints, and that is what underlies the possibility of reducing the CCPs to the simple intersecting of propositional contents of the normal sort.

9. ALMOST DYNAMICS + EPISTEMIC MODALS = REAL DYNAMICS

One of the recurring themes we have stressed is the idea that there is reason to think that epistemic modals involve some sort of non-truth-conditional comment on their prejacents. Of course, as we have also stressed, making good on this idea is no easy task—in no small part because epistemic modals seem to mix and combine remarkably well with other, seemingly truth-conditional,

[23] The general result is due to van Benthem (1986), but see also Groenendijk and Stokhof (1990) and van Benthem (1996). Sometimes eliminative functions are called INTROSPECTIVE and distributive functions are called CONTINUOUS.

constructions. And so a version of the Frege-Geach problem looms. But not in a dynamic treatment. As a bonus, we will turn our previous update semantics into a genuinely dynamic semantics.

The basic intuition we begin with is that epistemic *might* serves to comment that its prejacent is compatible with the contextually relevant body of information. That is, it serves to comment that there is a world in the relevant context in which the prejacent is true. But, the idea is, this comment does not contribute to the propositional content of modal expressions like *might* ϕ—such expressions do not really traffic in propositions of the normal sort. There is a natural way to model this idea in the world of CCPs, making it both more precise and less exotic.

When we think of programs, we naturally think of programs like **set the value of variable x to 1** that have some non-trivial impact. But there are also programs whose whole point is to leave things exactly as they find them, *testing* whether certain conditions are satisfied. For instance, in the complex program **if** ϕ **then** α **else** β we want to check and see if the condition described by ϕ obtains or not and we do that by composing the test $?\phi$ with the non-test α and the test $? \neg\phi$ with the non-test β. If we are thinking of the denotation of a program as its set of input-output pairs, then tests are just those programs that are defined only on the diagonal: they always return their input states (if anything).

That is the simplest way of adding epistemic modals to our fragment: think of them as tests on the information state.[24] First, let's extend our intermediate language to L, defined as the smallest set including our set of atomic sentences that is closed under negation, conjunction, and the one-place epistemic modal operator *might*. We then add a single clause to (22) to cover the new bits of our (slightly) more expressive language:

(29) UPDATE SEMANTICS FOR L
(a), (b), and (c) as in (22),
(d) $s[\![might\phi]\!]^{ccp} = \{w \in s : s[\![\phi]\!]^{ccp} \neq \emptyset\}$.

This says that $[\![might\phi]\!]$ will take an information state s and either return all of it, or none of it, depending on whether or not the condition is satisfied. The condition is that the information that ϕ

[24] This is, plus or minus a bit, the first update system introduced by Veltman (1996). See also van der Does *et al*. (1997), Beaver (2001: ch. 5); and Gillies (2001).

carries be compatible with s. In other words, we could equivalently put the test behavior of *might* this way:

(30) $s[\![might\phi]\!] = \begin{cases} s & \text{if } s[\![\phi]\!] \neq \emptyset \\ \emptyset & \text{otherwise} \end{cases}$

if s[[

i.e. we need a space between if and s

If we let *must* abbreviate the $\neg$ *might* $\neg$ in our intermediate language, then the following CCP follows immediately from (29):

(31) (e) $s[\![must\phi]\!]^{ccp} = \{w \in s : s[\![\phi]\!]^{ccp} = s\}$.

Thus we have that *might*-statements act as tests (checking to see if the information carried by their prejacents is compatible with the contextually relevant body of information), and *must*-statements act as dual tests (checking to see if the information carried by their prejacents is already present in the contextually relevant body of information).

In fact, we can say something a little more definitive. The modals here do behave as quantifiers over information states since the following holds:

(32) If ϕ is non-modal, then:
a. $s \models might\phi$ iff $s \cap [\![\phi]\!]^{classic} \neq\!=\emptyset$,
b. $s \models must\phi$ iff $s \subseteq [\![\phi]\!]^{classic}$.

delete equality sign, leave only the inequality sign

We might well wonder in what sense we have made good on the promise of making the comment-intuition precise if the CCPs we have here could, after all, be reduced to the kind of complicated statics like we saw above. For then we have would not have managed to get propositions out of the semantics for the modals after all. This semantics, however, is non-trivially dynamic. It is still, of course, eliminative since the new clause for *might* will always either return its input state or the empty set—either way $s[\![might\phi]\!] \subseteq s$. For present purposes we would not want to do away with that property, since we are interested in monotonic information exchange in which the set of possibilities in a state shrinks as the conversation moves forward. But $[\![\cdot]\!]^{ccp}$ doxes not distribute, and this is, as we would expect, because of the test behavior of the modals.

does

Here is a simple counterexample to distributivity. Let $s = \{w_1, w_2\}$ where ϕ is true at w_1 and false at w_2. Since $s[\![\phi]\!] \neq\!=\emptyset$, the test posed by *might* ϕ is one passed by s:

(33) $s[\![might\phi]\!] = s$.

delete equality sign, leave only the inequality sign

But we get a different result if we take the worlds that make up s, one at a time. Of course, since ϕ is true at w_1, $\{w_1\}$ will pass the test

posed by *might* ϕ. But w_2 will not. Since ϕ is false at w_2, $\{w_2\}[\![\phi]\!] = \emptyset$ and so $\{w_2\}[\![might\phi]\!] = \emptyset$. Thus we have:

(34) $\bigcup_{w \in s}\{w\}[\![might\phi]\!] = \{w_1\}$.

And these are different results.

One immediate consequence of this is that the CCPs associated with *might*-statements do not allow the kind of reduction we saw earlier. It is not generally true that:

(35) $s[\![might\phi]\!] = s \cap W[\![might\phi]\!]$.

And that means that $W[\![might\phi]\!]$ does not amount to the (static) propositional content of *might* ϕ. That is because *might*-statements, in this framework, make a kind of *global* comment about what is compatible with the current state. That is, they seem to say more about the information present than they do about the world. Which means that we cannot really factor out the current state from the interpretation in the way that we could in the static set-up. This way of making good on the intuition that epistemic modals involve a kind of comment dimension to them does not raise any Frege-Geach worries precisely because the semantic currency for the entire language—not just the modal stuff—is CCPs.[25] It just so happens that if we ignore the modals, those CCPs do not do anything that could not be done with propositions of the normal sort. But, as we have seen, things are different with the modals.

We also want to point out that although it can make perfect sense to assign *truth-conditions* to modal expressions—they, like the other sentences in our intermediate language, are true in a state iff that state is a fixed-point of the CCP—those truth-conditions are not about whether a proposition expressed by the sentence is true. So there is room to allow that epistemic modals have and contribute to truth-conditions, without requiring them to traffic in and express propositional contents. This is yet another way of exploring the idea that epistemic modals involve a kind of comment about the information carried by their prejacents.

[25] Of course, to really cash in on this claim, we would have to present dynamic semantic treatments of the whole panoply of embedding constructions that we used in section 4 to show that epistemic modals can embed. This goes way beyond what we can do in this paper, but the point is that there is no principled reason why this couldn't be done, whereas the embedding problem was severe for the two-dimensional approaches we considered there.

10. DYNAMIC EFFECTS IN NATURAL LANGUAGE

We seem to have checked our natural language interests at the door when we entered the world of CCPs. We want to now reclaim those interests, illustrating just a few ways in which the dynamic perspective is fruitful for thinking about epistemic modals.[26]

FN:26

We are throwing a party, and exactly two guests—Alex and Billy—have yet to arrive. They will arrive one at a time. Consider the following minimal pair, where the dots indicate a pause to see who is at the door:[27]

FN:27

(36) a. Billy might be at the door. . . . It isn't Billy at the door.
b. ?? It isn't Billy at the door. . . . Billy might be at the door.

Remember that we are limiting our attention to the monotonic shrinking of our uncertainty. We can interpret your utterance of (36a) perfectly smoothly. But things are different with (36b). Once we learn that Billy isn't at the door, it is very hard to interpret your claim that he might be. Assuming that a sequence of sentences is a conjunction of the sentences, and assuming the simple possible worlds treatment of modality, this asymmetry is rather unexpected. Letting ϕ be the atomic sentence *Billy is at the door* and B the epistemic conversational background:

(37) a. $[\![might(B)(\phi) \wedge \neg\phi]\!](w) = 1$ iff $w \in ([\![might(B)(\phi)]\!] \cap [\![\neg\phi]\!])$.
b. $[\![\neg\phi \wedge might(B)(\phi)]\!](w) = 1$ iff $w \in ([\![\neg\phi]\!] \cap [\![might(B)(\phi)]\!])$.

Given this analysis, there is no predicted asymmetry simply because set intersection is commutative. What we want, of course, is for the

[26] We won't go into it here, but the simple dynamic system here turns out to be pretty useful for thinking about some problems in formal epistemology as well. There is a well-known problem in belief dynamics—the Fuhrmann triviality result—that shows that conservative belief change is impossible for rational agents who have epistemic modal beliefs that are faithful to their non-modal beliefs. Diplomatically put: the dynamic perspective reveals an escape route that is hidden from view if we concentrate on revision models that have static entailment relations. Less diplomatically put: formal epistemology has a lot to learn from formal semantics. See Gillies (2006) for the details.

[27] This type of example is originally due to Veltman.

value of the conversational background B in (37b) to take into account the information introduced by the first conjunct—by the time we interpret *might* ϕ we have already learned that $\neg\phi$, and so B should not have any ϕ-worlds in it. Note that a consequence of this is that conjunction is not boolean intersection: $[\![\phi \wedge \mathit{might}(B)(\psi)]\!]^c$ is not, in general, $[\![\phi]\!]^c \cap [\![\mathit{might}(B)(\psi)]\!]^c$—$c$ may have to be ever so slightly shifted for interpreting B and so for assigning the right denotation to the second conjunct.

What this patch does in multiple steps is, in effect, exactly what the simple dynamic system above does in one step. Conjunction is interpreted not as intersection but as functional composition. So updating a state s with *might* ϕ and then with $\neg\phi$ will in general be very different from going the other way around. The former will, in many cases, be a fine way to proceed, but the latter will always result in a broken context, reducing the information state to absurdity.

A definition:

(38) a. A sentence CONSISTENT iff for some state s, updating s with the sentence does not result in absurdity.
b. ϕ is consistent iff for some s: $s[\![\phi]\!] \neq \emptyset$.

Otherwise, the sentence is inconsistent. The prediction, then, is that (36a) is consistent but (36a) is not.

But the dynamic perspective also allows us to make distinctions between (36a) and more run-of-the-mill conjunctions like:

(39) a. Billy is at the door and Alex is in traffic.
b. Alex might be at the door and Billy might be at the door.

These are also consistent. But they are different from (36a). There it was crucial that we learned some new information midway through, but there is no similar requirement here. The information these sentences carry can hang together all at once.

(40) a. A sentence COHESIVE iff there is a non-empty state that is a fixed-point of an update with it.
b. ϕ is cohesive iff for some $s \neq \emptyset$: $s[\![\phi]\!] = s$.

Clearly, cohesiveness implies consistency, but not the other way around.

Now we can mark the difference between (36a) and (39) easily: the latter are cohesive (and thus consistent) while the former is

FN:28 consistent but not cohesive.[28] The different information is crucial for keeping things running smoothly in that one. In the static framework, inconsistency and incohesiveness get lumped together. That is because ''consistency'' gets cashed out as ''possibly true''. But what we have here is a sort of case where a sentence like (36a) is not ''possibly true''—there is no non-absurd fixed-point of an update with it—but that does not mean adding the information it carries always results in a broken context. One thing the dynamic perspective allows us is the expressive tools to mark these kinds of differences.

Since *might*-statements are expressions of ignorance—in view of the relevant set of facts, the prejacent cannot be ruled out—if the relevant set of facts grows it should be no surprise that *might*-statements that were once called for might not be called for later. That is:

(41) a. A sentence is PERSISTENT iff: if it is true with respect to a state s and s' contains as much information as s, then it is true with respect to s'.

b. ϕ is persistent iff $s \models \phi$ and $s' \subseteq s$ imply $s' \models \phi$.

The prediction, of course, is that sentences like *might* ϕ are not persistent. For suppose s has just two worlds in it, w_1 a ϕ-world and w_2 a $\neg\phi$-world. Although *might* ϕ is true at s, it is not true at $\{w_2\}$ even though $\{w_2\} \subset s$. Like we said, that is not very surprising given that *might* test for compatibility between the information carried by its prejacent and the contextually relevant body of information.[29]

FN:29

Earlier we made a point of saying how epistemic modals are context sensitive and how that context-sensitivity ties in with *if*-clauses. We were highlighting just how tight the relationship is between context, modals, and other constructions. Of course, that *if*-clauses seem to function as restrictors for the conversational

[28] What we are calling ''cohesiveness'' is sometimes called COHERENCE. We prefer our term since there is nothing *incoherent* about (36a). It's just that what it says in the first conjunct doesn't stick to what it says in the second.

[29] The claim that epistemic modals are not persistent is not what's at stake in the debates between the ''semantic relativists'' mentioned in n. 1 and cooler heads. There the issue is over whether epistemic modals have context-dependent truth-conditions or whether they instead have some other more relativized kind of semantic value. Here the issue is over how stable the context-dependent truth-conditions end up being.

background is also a lot of trouble for some semantic theories. We want to now look briefly at this same phenomenon from the dynamic perspective.

Suppose we have lost our marbles. We have found all of them but two—the red one and the blue one—and know that exactly one of them is in the box. Thus:

(42) a. The marble in the box might be red, and might be blue.
b. If it's not red, it must be blue.
c. If it's not blue, it must be red.

In order to get these three sentences to all be true at once, there has to be some interaction between the *if*-clauses and the set of worlds that the modals act as (quantificational) tests on. Otherwise we get inconsistency. One way of doing this is to treat the *if*s as restrictors. But this simple dynamic semantics is another way. Take $\phi \rightarrow \psi$ to abbreviate $\neg(\phi \wedge \neg\psi)$, and treat the modals as having narrow scope in the conditionals, and you can easily show that all of these sentences are true in a state containing just two worlds: one a red-is-in-the-box world, and the other a blue-is-in-the-box world.[30] Having just assigned some homework, we think this is a good place to stop and sum up.

FN:30

CONCLUSION

We began by noting that epistemic modals are interesting in part because their semantics is bound up both with our information about the world and with how that information changes as we share what we know. Our aim here has been to survey some of that territory. We have seen that epistemic readings of modal expressions are instantiations of a core meaning that is contextually filled in. They serve as evidential comments on the prejacent proposition, whose being put forward is often the *main point* of the utterance. They typically signal the presence of an indirect inference. Of course, there are a number of options open for exploring some of these issues, complicating the standard possible worlds approach in various ways. In the case of thinking of epistemic

2007

[30] See Gillies (2006) for more on this and other puzzles about *if*s and modals.

modals as contributing more to *comments* than *contents*, we can complicate the semantic apparatus by including a distinct semantic dimension where comments live, we can complicate the pragmatics by saying that in uttering a modal a speaker manages to perform multiple speech acts, or we can redistribute some of the interpretive workload between the compositional semantics and pragmatics by making the semantics traffic in CCPs instead of contents. We have reservations about whether the first path here is really an option since embedding facts seem to doom it. The other two paths may well be related—the dynamic perspective is certainly the one that has been subjected to more formalization—but that sounds more like an open question than like material for a paper with our title.

REFERENCES

Beaver, David (2001) *Presupposition and Assertion in Dynamic Semantics*. Stanford, Calif.: CSLI.

van Benthem, Johan (1986) *Essays in Logical Semantics*. Studies in Linguistics and Philosophy (SLAP), 29. Dordrecht: Reidel.

____ (1996) *Exploring Logical Dynamics*. Stanford, Calif.: Center for the Study of Language and Information (CSLI).

Blain, Eleanor, and Dechaine, Rose-Marie (2005) 'Evidential Marking across the Cree Dialect Continuum'. To appear in *International Journal of American Linguistics*.

Copeland, B. Jack (2002) 'The Genesis of Possible Worlds Semantics', *Journal of Philosophical Logic*, 31(2): 99–137. doi:10.1023/A:1015273407895.

van der Does, Jaap, Groeneveld, Willem, and Veltman, Frank (1997) 'An Update on *Might*', *Journal of Logic, Language and Information*, 6(4): 361–80. doi:10.1023/A:1008219821036.

Egan, Andy (2005) 'Epistemic Modals, Relativism, and Assertion', in Gajewski *et al*. (2005). ~~URL http://www.sitemaker.umich.edu/egana/files/mitwpl.proof.pdf.~~

____ Hawthorne, John, and Weatherson, Brian (2005) 'Epistemic Modals in Context', in Gerhard Preyer and Georg Peter (eds.) *Contextualism in Philosophy: Knowledge, Meaning, and Truth*, pp. 131–70. Oxford: Oxford University Press. ~~Preprint http://brian.weatherson.org/em.pdf.~~

von Fintel, Kai (2005) 'Modality and Language', in Donald M. Borchert (2nd edn.) *Encyclopedia of Philosophy*, Macmillan. URL http://mit.edu/fintel/modality.pdf.

____ and Gillies, Anthony S. (2007) 'CIA Leaks', MS, MIT and University of Michigan, to appear in the *Philosophical Review*.

Eleanor M. Blain & Rose-Marie Déchaine. 2007. "Evidential Types: Evidence from Cree Dialects". International Journal of American Linguistics, 73(3): 257–291. doi: 10.1086/521728.

2007a

PLEASE ADD THIS REFERENCE (note: 'Might' should be set in italics!)

_____ and _____ (2007b) 'Might Made Right', MS, MIT and University of Michigan, forthcoming in an OUP volume on epistemic modals, edited by Brian Weatherson and Andy Egan.

____ and Iatridou, Sabine (2003) 'Epistemic Containment', *Linguistic Inquiry*, 34(2): 173–98. doi:10.1162/002438903321663370.

____ and ____ (2006) 'How to Say ''Ought'' in Foreign: The Composition of Weak Necessity Modals', MS, MIT, to appear in Jacqueline Guéron and Jacqueline Lecarne (eds.), *Time and Modality* (Dordrecht).

Frege, Gottlob (1879) *Begriffsschrift, eine der arithmetischen nachgebildete Formelsprache des reinen Denkens*. Halle: L. Nebert. Tr. by Stefan Bauer-Mengelberg, from Jean van Heijenoort (ed.), *From Frege to Gödel: A Source Book in Mathematical Logic, 1879–1931*, Cambridge, Mass.: Harvard University Press. 1967.

Gajewski, Jon, Hacquard, Valentine, Nickel, Bernard, and Yalcin, Seth (eds.) (2005) *New Work on Modality*. MIT Working Papers in Linguistics, 52. Department of Linguistics and Philosophy, MIT.

Need to reorder these two references: Gillies (2007) and Gillies (2006)

Gillies, Anthony S. (2001) 'A New Solution to Moore's Paradox', *Philosophical Studies*, 105(3): 237–50. doi:10.1023/A:1010361708803. ~~URL~~ http://www-personal.umich.edu/~thony/moore.pdf.

2007

____ (2006) 'Iffiness', MS, University of Michigan.

____ (2006) 'What Might be the Case After a Change in View', *Journal of Philosophical Logic*, 35(2): 117–45. doi:10.1007/s10992-005-9006-7.

Groenendijk, Jeroen and Stokhof, Martin (1990) 'Two Theories of Dynamic Semantics', in Jan van Eijck (ed.) *Logics in AI*, pp. 55–64. Berlin: Springer.

____ and ____ (1991) 'Dynamic Predicate Logic', *Linguistics and Philosophy*, 14(1): 39–100. doi:10.1007/BF00628304. ~~URL http://staff.~~ science.uva.nl/~stokhof/papers/dpl.pdf.

Harel, David, Kozen, Dexter, and Tiuryn, Jerzy (2000) *Dynamic Logic*. Cambridge, Mass.: MIT Press.

Heim, Irene (1982) '*The Semantics of Definite and Indefinite Noun Phrases*', Ph.D. thesis, University of Massachusetts at Amherst. URL http://semanticsarchive.net/Archive/Tk0ZmYyY/dissertation.pdf.

Hintikka, Jaakko (1962) *Knowledge and Belief*. Ithaca, NY: Cornell University Press.

Kamp, Hans (1981) 'A Theory of Truth and Semantic Interpretation', in Jeroen Groenendijk, Theo Janssen, and Martin Stokhof (eds.), *Formal Methods in the Study of Language*, pp. 277–322. Amsterdam: Mathematical Centre.

Kant, Immanuel (1781) *Critik der reinen Vernunft*. Riga: Johann Friedrich Hartknoch.

Karttunen, Lauri (1972) 'Possible and Must', in J. Kimball (ed.) *Syntax and Semantics*, i. 1–20. New York: Academic Press. ~~URL http://www2.parc.com/istl/members/karttune/publications/archive/possible.pdf.~~

Karttunen, Lauri (1974) 'Presupposition and Linguistic Context', *Theoretical Linguistics*, 1: 181–93. URL http://www2.parc.com/istl/members/karttune/publications/archive/presupplingcontext.pdf.

Kratzer, Angelika (1977) 'What *Must* and *Can* Must and Can Mean', *Linguistics and Philosophy*, 1(3): 337–55. doi:10.1007/BF00353453.

____ (1978) *Semantik der Rede: Kontexttheorie—Modalwörter—Konditionalsätze*. Königstein/Taunus: Scriptor.

____ (1981) 'The Notional Category of Modality', in H. J. Eikmeyer and H. Rieser (eds.), *Words, Worlds, and Contexts: New Approaches in Word Semantics*, pp. 38–74. Berlin: de Gruyter.

____ (1991) 'Modality', in Arnim von Stechow and Dieter Wunderlich (eds.), *Semantics: An International Handbook of Contemporary Research*, pp. 639–50. Berlin: de Gruyter.

Kripke, Saul (1963) 'Semantical Analysis of Modal Logic I: Normal Modal Propositional Calculi', *Zeitschrift für mathematische Logik und Grundlagen der Mathematik*, 9: 67–96.

Lewis, David (1979) 'Scorekeeping in a Language Game', *Journal of Philosophical Logic*, 8(1): 339–59. doi:10.1007/BF00258436.

MacFarlane, John (2003) 'Epistemic Modalities and Relative Truth', URL http://sophos.berkeley.edu/macfarlane/epistmod-2003.pdf.

____ (2006) 'Epistemic Modals are Assessment-Sensitive', URL http://sophos.berkeley.edu/macfarlane/epistmod.pdf. MS, University of California, Berkeley, forthcoming in an OUP volume on epistemic modals, edited by Brian Weatherson and Andy Egan.

Matthewson, Lisa, Rullmann, Hotze, and Davis, Henry (2006) 'Evidentials are Epistemic Modals in St'a?t'imcets', MS, University of British Columbia.

Potts, Christopher (2005) *The Logic of Conventional Implicatures*. Oxford: Oxford University Press.

Simons, Mandy (2006) 'Observations on Embedding Verbs, Evidentiality, and Presupposition', *Lingua*. doi:10.1016/j.lingua.2006.05.006. URL http://www.hss.cmu.edu/philosophy/simons/embedding%20verbs.submitted.pdf.

Stalnaker, Robert (1978) 'Assertion', in Peter Cole (ed.) *Syntax and Semantics*, 9: 315–22. New York: Academic Press.

Stephenson, Tamina (2005) 'Assessor Sensitivity: Epistemic Modals and Predicates of Personal Taste', in Gajewski *et al*. (2005). URL http://semanticsarchive.net/Archive/WE5NzVhN.

Swanson, Eric (2005) 'Something *Might* Might Mean', URL http://tinyurl.com/y5g22m. MS, MIT.

Veltman, Frank (1985) '*Logics for Conditionals*', Ph.D. thesis, University of Amsterdam.

____ (1996) 'Defaults in Update Semantics', *Journal of Philosophical Logic*, 25(3): 221–61. doi:10.1007/BF00248150.

Willett, Thomas (1988) 'A Cross-Linguistic Survey of the Grammaticalization of Evidentiality', *Studies in Language*, 12(1): 51–97.

Yalcin, Seth (2005) 'Epistemic Modals', in Gajewski *et al*. (2005). ~~URL~~ ~~http://mit.edu/yalcin/www/epmodal-dec05.pdf.~~