

INTENSIONAL SEMANTICS

LECTURE NOTES

KAI VON FINTEL

IRENE HEIM

MIT SPRING 2005 EDITION

note about the lecture notes:

The notes for this course have been evolving for years now, starting with some notes from the early 1990s by Angelika Kratzer, Irene Heim, and myself, which have since been modified and expanded every year by Irene or myself. Because this version of the notes has not been seen by my co-author, I alone am responsible for any defects.

Heidi von Stechow, January 2005

This is a work in progress. We may eventually publish these materials as a follow-volume to Heim & Kratzer's *Semantics in Generative Grammar*, Blackwell 1998. In the meantime, we encourage the use of these notes in courses at other institutions. Of course, you need to give full credit to the authors and you may not use the notes for any commercial purposes. If you use the notes, we would like to be notified and we would very much appreciate any comments, criticism, or advice on these materials.

Direct your communication to:

Heidi von Stechow
Department of Linguistics & Philosophy
Massachusetts Institute of Technology

Advice about using these notes

1. These notes presuppose familiarity with the material, concepts, and notation of the Heim & Kratzer textbook.
2. There are numerous exercises throughout the notes. It is highly recommended to do all of them and it is certainly necessary to do so if you anticipate doing semantics-related work in the future.
3. At the moment, the notes are designed to go along with explanatory lectures. You should ask questions and make comments as you work through the notes.
4. Students with semantic ambitions should also at an early point start reading supplementary material (as for example listed at the end of each chapter of these notes).
5. Lastly, prospective semanticists may start thinking about how *they* will teach this material.

— THIS PAGE INTENTIONALLY LEFT BLANK —

| | | |
|----------|---|-----------|
| 1 | Beginnings of Intensional Semantics | 1 |
| 1.1 | Displacement | 1 |
| 1.2 | An Intensional Semantics in 10 Easy Steps | 3 |
| 1.3 | Comments and Complications | 10 |
| | Supplemental Readings | 13 |
| 2 | Propositional Attitudes | 17 |
| 2.1 | Hintikka's Idea | 17 |
| 2.2 | Accessibility Relations | 20 |
| 2.3 | A Note on Shortcomings | 22 |
| | Supplemental Readings | 22 |
| 3 | Modality | 25 |
| 3.1 | The Quantificational Theory of Modality | 25 |
| 3.2 | Flavors of Modality | 28 |
| 3.3 | Kratzer's Conversational Backgrounds | 37 |
| | Supplemental Readings | 40 |
| 4 | Conditionals | 43 |
| 4.1 | The Material Implication Analysis | 43 |
| 4.2 | The Strict Implication Analysis | 46 |
| 4.3 | <i>If</i> -Clauses as Restrictors | 48 |
| | Supplemental Readings | 50 |
| 5 | Ordering | 53 |
| 5.1 | The Driveway | 53 |
| 5.2 | Kratzer's Solution: Doubly Relative Modality | 54 |
| 5.3 | The Paradox of the Good Samaritan | 56 |
| 5.4 | Kratzer's Version of the Samaritan Paradox | 57 |
| 5.5 | Non-Monotonicity of Conditionals | 57 |
| | Supplemental Readings | 59 |
| 6 | DPs and Scope in Modal Contexts | 61 |
| 6.1 | <i>De re</i> vs. <i>De dicto</i> as a Scope Ambiguity | 61 |
| 6.2 | Raised subjects | 65 |

— THIS PAGE INTENTIONALLY LEFT BLANK —

— THIS PAGE INTENTIONALLY LEFT BLANK —

BEGINNINGS OF INTENSIONAL S

We introduce the idea of extension vs. intension and its main use: taking us from the actual here and now to past, future, possible, counterfactual situations. We develop a compositional framework for intensional semantics.

Contents

| | | |
|-------|---|----|
| 1.1 | Displacement | 1 |
| 1.2 | An Intensional Semantics in 10 Easy Steps | 3 |
| 1.2.1 | Laying the Foundations | 3 |
| 1.2.2 | Intensional Operators | 6 |
| 1.3 | Comments and Complications | 10 |
| 1.3.1 | Intensions All the Way? | 10 |
| 1.3.2 | Why Talk about Other Worlds? | 11 |
| 1.3.3 | The Worlds of Sherlock Holmes | 12 |
| | Supplemental Readings | 13 |

1.1 Displacement

Hockett [34, 35] in a famous article (and a follow-up) presented a list of DESIGN FEATURES OF HUMAN LANGUAGE. This list continues to play a role in current discussions of animal communication. One of the design features is DISPLACEMENT. Human language is not restricted to discourse about the *actual here and now*.

How does natural language untie us from the actual here and now? One degree of freedom is given by the ability to name entities and refer to them even if they are not where we are when we speak:

- (1) Thomas is in Hamburg.

This kind of displacement is not something we will explore here. We'll take it for granted.

Consider a sentence with no names of absent entities in it:

- (2) It is snowing (in Cambridge).

On its own, (2) makes a claim about what is happening right now here in Cambridge. But there are devices at our disposal that can be added to (2), resulting in claims about snow in displaced situations. Displacement can occur in the TEMPORAL dimension and/or in what might be called the MODAL* dimension. Here's an example of temporal displacement:

- (3) At noon yesterday, it was snowing in Cambridge.

This sentence makes a claim not about snow now but about snow at noon yesterday, a different time from now.

Here's an example of modal displacement:

- (4) If the storm system hadn't been deflected by the jet stream, it would have been snowing in Cambridge.

This sentence makes a claim not about snow in the actual world but about snow in the world as it would have been if the storm system hadn't been deflected by the jet stream, a world distinct from the actual one (where the system did not hit us), a merely POSSIBLE WORLD.

Natural language abounds in modal constructions. (4) is a so-called COUNTERFACTUAL CONDITIONAL. Here are some other examples:

- (5) MODAL AUXILIARIES
It may be snowing in Cambridge.
- (6) MODAL ADVERBS
Possibly, it will snow in Cambridge tomorrow.
- (7) PROPOSITIONAL ATTITUDES
Jens believes that it is snowing in Cambridge.
- (8) HABITUALS
Jane smokes.
- (9) GENERICS
Bears like honey.

The plan for this course is as follows. In Part 1, we explore modality and associated topics. In Part 2, we explore temporal matters.

In this chapter, we will put in place the basic framework of intensional semantics. To do this, we will start with one rather special example of modal displacement:

(10) In the world of Sherlock Holmes, a detective lives at 221B Baker Street.

(10) doesn't claim that a detective lives at 221B Baker Street in the actual world (presumably a false claim), but that in the world as it is described in the Sherlock Holmes stories of Sir Arthur Conan Doyle, a detective lives at 221B Baker Street (a true claim, of course). We choose this example rather than one of the more run-of-the-mill displacement constructions because we want to focus on conceptual and technical matters before we do serious empirical work.

The questions we want to answer are: How does natural language achieve this feat of modal displacement? How do we manage to make claims about other possible worlds? And why would we want to? Our task in the rest of this chapter is to put in place a framework for intensional semantics with which we can explore modal displacement.

1.2 An Intensional Semantics in 10 Easy Steps

1.2.1 Laying the Foundations

STEP 1: POSSIBLE WORLDS. Our first step is to introduce possible worlds. This is not the place to discuss the metaphysics of possible worlds in any depth. Instead, we will just start working with them and see what they can do for us. Basically, a possible world is a way that things might have been. In the actual world, there are two coffee mugs on my desk, but there could have been more or less. So, there is a possible world – albeit a rather bizarre one – where there are 17 coffee mugs on my desk. We join Heim & Kratzer in adducing this quote from David Lewis [55:If.]:

The world we live in is a very inclusive thing. Every stick and every stone you have ever seen is part of it. And so are you and I. And so are the planet Earth, the solar system, the entire Milky Way, the remote galaxies we see through telescopes, and (if there are such things) all the bits of empty space between the stars and galaxies. There is nothing so far away from us as not to be part of our world. Anything at any distance at all is to be included. Likewise the world is inclusive in time. No long-gone ancient Romans, no long-gone pterodactyls, no long-gone primordial clouds of plasma are too far in the past, nor are the dead dark stars too far in the future, to be part of the same world. ...

The way things are, at its most inclusive, means the way the entire world is. But things might have been different, in ever so many ways. This book of mine might have been finished on schedule. Or, had I not been such a commonsensical chap, I might be defending not only a plurality of possible worlds, but also a plurality of

impossible worlds, whereof you speak truly by contradicting yourself. Or I might not have existed at all – neither myself, nor any counterparts of me. Or there might never have been any people. Or the physical constants might have had somewhat different values, incompatible with the emergence of life. Or there might have been altogether different laws of nature; and instead of electrons and quarks, there might have been alien particles, without charge or mass or spin but with alien physical properties that nothing in this world shares. There are ever so many ways that a world might be: and one of these many ways is the way that this world is.

Previously, our “metaphysical inventory” included a domain of entities and a set of two truth-values and increasingly complex functions between entities, truth-values, and functions thereof. Now, we will add possible worlds to the inventory. Let’s assume we are given a set W , the set of all possible worlds, which is a vast space since there are so many ways that things might have been different from the way they are. Each world has as among its parts entities like you and me and these coffee mugs. Some of them may not exist in other possible worlds. So, strictly speaking each possible world has its own, possibly distinctive, domain of entities. What we will use in our system, however, will be the grand union of all these world-specific domains of entities. We will use D to stand for the set of all possible individuals.

Among the many possible worlds that there are – according to Lewis, there is a veritable plenitude of them – is the world as it is described in the Sherlock Holmes stories by Sir Arthur Conan Doyle. In that world, there is a famous detective Sherlock Holmes, who lives at 221B Baker Street in London and has a trusted sidekick named Dr. Watson. Our sentence *In the world of Sherlock Holmes, a detective lives at 221B Baker Street* displaces the claim that a famous detective lives at 221B Baker Street from the actual world to the world as described in the Sherlock Holmes stories. In other words, the following holds:¹

- (II) The sentence *In the world of Sherlock Holmes, a detective lives at 221B Baker Street* is true in a world w iff the sentence *a detective lives at 221B Baker Street* is true in the world as it is described in the Sherlock Holmes stories.

What this suggests is that we need to make space in our system for having devices that control in what world a claim is evaluated. This is what we will do now.

STEP 2: THE EVALUATION WORLD PARAMETER. Recall from H&K that we were working with a semantic interpretation function that was relativized to an assign-

¹ We will see in Section 1.3.2 that this is not quite right. It’ll do for now.

ment function g , which was needed to take care of pronouns, traces, variables, etc. From now, on we will relativize the semantic values in our system to possible worlds as well. What this means is that from now on our interpretation function will have two superscripts: a world w and an assignment g : $\llbracket \cdot \rrbracket^{w,g}$.

So, a sentence like the one embedded in (10) will have its truth-conditions described as follows:

- (12) $\llbracket \text{a famous detective lives at 221B Baker Street} \rrbracket^{w,g} = 1$
iff a famous detective lives at 221B Baker Street in world w .

It is customary to refer to the world for which we are calculating the extension of a given expression as the **EVALUATION WORLD**. In the absence of any shifting devices, we would normally evaluate a sentence in the actual world. But then there are shifting devices such as our *in the world of Sherlock Holmes*. We will soon see how they work. But first some more pedestrian steps: adding lexical entries and composition principles that are formulated relative to a possible world. This will allow us to derive the truth-conditions as stated in (12) in a compositional manner.

STEP 3: LEXICAL ENTRIES. Among our lexical items, we can distinguish between items which have a world-dependent semantic value and those that are world-independent. Predicates are typically world-dependent. Here are some sample entries.

- (13) For any $w \in W$ and any assignment function g :
- a. $\llbracket \text{famous} \rrbracket^{w,g} = \lambda x \in D. x \text{ is famous in } w.$
 - b. $\llbracket \text{detective} \rrbracket^{w,g} = \lambda x \in D. x \text{ is a detective in } w.$
 - c. $\llbracket \text{lives-at} \rrbracket^{w,g} = \lambda x \in D. \lambda y \in D. y \text{ lives-at } x \text{ in } w.$

The set of detectives will obviously differ from world to world, and so will the set of famous individuals and the set of pairs where the first element lives at the second element.

Other items have semantic values which do not differ from world to world. The most important such items are certain “logical” expressions, such as truth-functional connectives and determiners:

- (14) a. $\llbracket \text{and} \rrbracket^{w,g} = \lambda u \in D_t. \lambda v \in D_t. u = v = 1.$
 b. $\llbracket \text{the} \rrbracket^{w,g} = \lambda f \in D_{\langle e,t \rangle} : \exists! x. f(x) = 1. \text{ the } y \text{ such that } f(y) = 1.$
 c. $\llbracket \text{every} \rrbracket^{w,g} = \lambda f \in D_{\langle e,t \rangle}. \lambda g \in D_{\langle e,t \rangle}. \forall x \in D : f(x) = 1 \rightarrow g(x) = 1.$
 d. $\llbracket \text{a/some} \rrbracket^{w,g} = \lambda f \in D_{\langle e,t \rangle}. \lambda g \in D_{\langle e,t \rangle}. \exists x \in D : f(x) = 1 \ \& \ g(x) = 1.$

Note that there is no occurrence of w on the right-hand side of the entries in (14). That's the tell-tale sign of the world-independence of the semantics of these items.

We will also assume that proper names have world-independent semantic values, that is, they refer to the same individual in any possible world.

- (15)
- a. $\llbracket \text{Noam Chomsky} \rrbracket^{w,g} = \text{Noam Chomsky.}$
 - b. $\llbracket \text{Sherlock Holmes} \rrbracket^{w,g} = \text{Sherlock Holmes.}$
 - c. $\llbracket 221B \text{ Baker Street} \rrbracket^{w,g} = 221B \text{ Baker Street.}$

STEP 4: COMPOSITION PRINCIPLES. The old rules of Functional Application, Predicate Modification, and λ -Abstraction can be retained almost intact. We just need to modify and add world-superscripts to the interpretation function. For example:

- (16) FUNCTIONAL APPLICATION (FA)
- If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any world w and assignment g : if $\llbracket \beta \rrbracket^{w,g}$ is a function whose domain contains $\llbracket \gamma \rrbracket^{w,g}$, then $\llbracket \alpha \rrbracket^{w,g} = \llbracket \beta \rrbracket^{w,g}(\llbracket \gamma \rrbracket^{w,g})$.

The rule simply passes the world parameter down.

STEP 5: TRUTH. Lastly, we will want to connect our semantic system to the notion of the TRUTH OF AN UTTERANCE. This is done by the following principle:

- (17) TRUTH OF AN UTTERANCE
- An utterance of a sentence ϕ in a possible world w is true iff $\llbracket \phi \rrbracket^{w,\emptyset} = \text{I.}^2$

EXERCISE 1.1: Compute under what conditions an utterance in possible world w_7 (which may or may not be the one we are all living in) of the sentence *a famous detective lives at 221B Baker Street* is true. [Since this is the first exercise of the semester, please do this in excruciating detail, not skipping any steps.] \square

1.2.2 Intensional Operators

So far we have merely redecorated our old system inherited from last semester. We have introduced possible worlds into our inventory, our lexical entries and our old composition principles. But with the tools we have now, all we can do so far is to keep track of the world in which we evaluate the semantic value of an expression, complex or lexical. We will get real mileage once we introduce INTENSIONAL OPERATORS which are capable of shifting the world parameter. We

² Recall from Heim & Kratzer that the empty assignment function \emptyset is one that is undefined for any variable index. So, this notion of truth of an utterance presupposes that there are no free variables in ϕ to be taken care of. The alternative is to make reference to an assignment function salient in the context of the utterance.

introduced a number of devices for modal displacement. As advertised, for now, we will just focus on a very particular one: the expression *in the world of Sherlock Holmes*. We will assume, as seems reasonable, that this expression is a sentence-modifier both syntactically and semantically.

STEP 6: A SYNCATEGOREMATIC ENTRY. We begin with a heuristic step. We want to derive something like the following truth-conditions for our sentence:

- (18) $\llbracket \text{in the world of Sherlock Holmes, a famous detective lives at 221B Baker Street} \rrbracket^{w,g} = 1$
iff the world w' as it is described in the Sherlock Holmes stories is such that there exists a famous detective in w' who lives at 221B Baker Street in w' .

We would get this if in general we have this rule for *in the world of Sherlock Holmes*:

- (19) For any sentence ϕ , any world w , and any assignment g :
 $\llbracket \text{in the world of Sherlock Holmes } \phi \rrbracket^{w,g} = 1$
iff the world w' as it is described in the Sherlock Holmes stories is such that $\llbracket \phi \rrbracket^{w',g} = 1$.

This is a so-called SYNCATEGOREMATIC entry. What this means is that in (19) we do not compute the meaning for *in the world of Sherlock Holmes*, ϕ from the combination of the meanings of its parts, since *in the world of Sherlock Holmes* is not given a separate meaning, but in effect triggers a special composition principle. This format is very common in modal logic systems which usually give a semantics for two modal operators (the necessity operator \Box and the possibility operator \Diamond). When one only has a few closed class expressions to deal with that may shift the world parameter, employing syncategorematic entries is a reasonable strategy. But we are facing a multitude of displacement devices. So, we will need to make our system more modular.

So, we want to give *in the world of Sherlock Holmes* its own meaning and combine that meaning with that of its sister by a general composition principle. The Fregean slogan we adopted says that all composition is function application (modulo the need for λ -abstraction and the possible need for predicate modification). So, what we will want to do is to make (18) be the result of functional application. But we can immediately see that it cannot be the result of our usual rule of functional application, since that would feed to *in the world of Sherlock Holmes* the semantic value of *a famous detective lives in 221B Baker Street* in w , which would be a particular truth-value, 1 if a famous detective lives at 221B Baker Street in w and 0 if there doesn't. And whatever the semantics of *in the world of Sherlock Holmes* is, it is certainly *not* a truth-functional operator.

So, we need to feed something else to *in the world of Sherlock Holmes*. At the same time, we want the operator to be able to shift the evaluation world of its argument. Can we do this?

STEP 7: INTENSIONS. Guess what? We already have what we need. Our system actually provides us with two kinds of meanings. For any expression α , we have $\llbracket \alpha \rrbracket^{w,g}$, the semantic value of α in w , also known as the EXTENSION of α in w . But we can also calculate $\lambda w. \llbracket \alpha \rrbracket^{w,g}$, the function that assigns to any world w the extension of α in that world. This is usually called the INTENSION of α . We will sometimes use an abbreviatory notation³ for the intension of α :

$$(20) \quad \llbracket \alpha \rrbracket_c^g := \lambda w. \llbracket \alpha \rrbracket^{w,g}.$$

It should be immediately obvious that since the definition of intension abstracts over the evaluation world, intensions are not world-dependent.^{4,5}

Before we say more about intensions, here's a sketch of how they are going to help us solve our puzzle. We will feed the intension of the embedded sentence to the shifting operator. The crucial part is that the intension can be applied to any world and give the truth-value of the sentence in that world. The operator will use that intension and apply it to the world it wants the evaluation to happen in. Voilà.

Note that strictly speaking, it now makes no sense anymore to speak of “*the* semantic value” of an expression α . What we have is a semantic system that allows us to calculate extensions (for a given possible world w) as well as intensions for all (interpretable) expressions. We will see that when α occurs in a particular bigger tree, it will always be determinate which of the two “semantic values” of α is the one that enters into the compositional semantics. So, that one – whichever one it is, the extension or the intension of α – might then be called “*the* semantic value of α in the tree β ”.

It should be noted that the terminology of EXTENSION vs. INTENSION is time-honored but that the possible worlds interpretation thereof is more recent. The technical notion we are using is certainly less rich a notion of meaning than tradition assumed.

³ The notation with the subscripted cent-sign comes from Montague Grammar. See e.g. Dowty et al. [14:147].

⁴ Since intensions are by definition not dependent on the choice of a particular world, it makes no sense to put a world-superscript on the intension-brackets. So don't ever write “ $\llbracket \dots \rrbracket_c^{w,g}$ ”; we'll treat that as undefined nonsense.

⁵ The definition here is simplified, in that it glosses over the fact that some expressions, in particular those that contain PRESUPPOSITION TRIGGERS, may fail to have an extension in certain worlds. In such a case, the intension has no extension to map such a world to. Therefore, the intension will have to be a partial function. So, the official, more “pedantic”, definition will have to be as follows: $\llbracket \alpha \rrbracket_c^g := \lambda w : \alpha \in \text{dom}(\llbracket \dots \rrbracket^{w,g}). \llbracket \alpha \rrbracket^{w,g}$.

STEP 8: SEMANTIC TYPES. If we want to be able to feed the intensions to lexical items like *in the world of Sherlock Holmes*, we need to have the appropriate types in our system.

Recall that W is the set of all possible worlds. And recall that D is the set of all POSSIBLE INDIVIDUALS and thus contains all individuals existing in the actual world *plus* all individuals existing in any of the merely possible worlds.

We now expand the set of semantic types, to add intensions. Intensions are functions from possible worlds to all kinds of extensions. So, basically we want to add for any kind of extension we have in our system, a corresponding kind of intension, a function from possible worlds to that kind of extension. We do this as follows:

(21) SEMANTIC DOMAINS

- a. $D_e = D$, the set of all possible individuals
- b. $D_t = \{0, 1\}$, the set of truth-values
- c. If a and b are semantic types, then $D_{\langle a, b \rangle}$ is the set of all functions from D_a to D_b .
- d. If a is a type, then $D_{\langle s, a \rangle}$ is the set of all functions from W to D_a .

The functions of the schematics type $\langle s, \dots \rangle$ are intensions. Note a curious feature of this set-up: there is no type s and no associated domain. This corresponds to the assumption that there are no expressions of English that take as their extension a possible world, that is, there are no pronouns or names referring to possible worlds. We will actually question this assumption in a later chapter. For now, we will stay with this more conventional set-up.

Here are some examples of intensions:

- The intensions of sentences are of type $\langle s, t \rangle$, functions from possible worlds to truth values. These are usually called PROPOSITIONS. Note that if the function is total, then we can see the sentence as picking out a set of possible worlds, those in which the sentence is true. More often than not, however, propositions will be partial functions from worlds to truth-values, which fail to map certain possible worlds into either truth-value. This will be the case when the sentence contains a presupposition trigger, such as *the*. The famous sentence *The King of France is bald* has an intension that is undefined for any world where there fails to be a unique King of France.
- The intensions of one-place predicates are of type $\langle s, \langle e, t \rangle \rangle$, functions from worlds to set of individuals. These are usually called PROPERTIES.
- The intensions of expressions of type e are of type $\langle s, e \rangle$, functions from worlds to individuals. These are usually called INDIVIDUAL CONCEPTS.

STEP 9: A LEXICAL ENTRY FOR A SHIFTER. We are ready to formulate the semantic entry for *in the world of Sherlock Holmes*.⁶

- (22) $\llbracket \text{in the world of Sherlock Holmes} \rrbracket^{w,g} =$
 $\lambda p_{\langle s,t \rangle}. \text{the world } w' \text{ as it is described in the Sherlock Holmes stories}$
 $\text{is such that } p(w') = 1.$

Now, *in the world of Sherlock Holmes* expects as its argument a function of type $\langle s, t \rangle$, a proposition. It yields the truth-value 1 iff the proposition is true in the world as it is described in the Sherlock Holmes stories.

All that's left to do now is to provide *in the world of Sherlock Holmes* with a proposition as its argument. This is the job of a new composition principle.

STEP 10: INTENSIONAL FUNCTIONAL APPLICATION. We add the new rule of Intensional Functional Application.

- (23) INTENSIONAL FUNCTIONAL APPLICATION (IFA)
 If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any world w and assignment g : if $\llbracket \beta \rrbracket^{w,g}$ is a function whose domain contains $\llbracket \gamma \rrbracket_k^g$, then $\llbracket \alpha \rrbracket^{w,g} = \llbracket \beta \rrbracket^{w,g}(\llbracket \gamma \rrbracket_k^g)$.

This is the crucial move. It makes space for expressions that want to take the intension of their sister as their argument and do stuff to it. Now, everything is in place. Given (22), the semantic argument of *in the world of Sherlock Holmes* will not be a truth-value but a proposition. And thus, *in the world of Sherlock Holmes* will be able to check the truth-value of its complement in various possible worlds. To see in practice that we have all we need, please do the following exercise.

EXERCISE 1.2: Calculate the conditions under which an utterance in a given possible world w_7 of the sentence *in the world of the Sherlock Holmes stories, a famous detective lives at 221B Baker Street* is true. \square

1.3 Comments and Complications

1.3.1 Intensions All the Way?

We have seen that to adequately deal with expressions like *in the world of Sherlock Holmes*, we need an intensional semantics, one that gives us access to the extensions of expressions across the multitude of possible worlds. At the same time, we have kept the semantics for items like *and*, *every*, and *a* unchanged and extensional. This is not the only way one can set up an intensional semantics. The following exercise demonstrates this.

⁶ This is not yet the final semantics, see Section 1.3 for complications.

EXERCISE 1.3: Consider the following “intensional” meaning for *and*:

$$(24) \quad \llbracket \text{and} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle} . \lambda q_{\langle s,t \rangle} . p(w) = q(w) = 1.$$

With this semantics, *and* would operate on the intensions of the two conjoined sentences. In any possible world w , the complex sentence will be true iff the component propositions are both true of that world.

Compute the truth-conditions of the sentence *In the world of Sherlock Holmes, Holmes is quick and Watson is slow* both with the extensional meaning for *and* given earlier and the intensional meaning given here. Is there any difference in the results? \square .

There are then at least two ways one could develop an intensional system.

- (i) We could “generalize to the worst case” and make the semantics deliver intensions as *the* semantic value of an expression. Such systems are common in the literature, see Cresswell [11], Lewis [49].
- (ii) We could maintain much of the extensional semantics we have developed so far and extend it conservatively so as to account for non-extensional contexts.

We have chosen to pursue (ii) over (i), because it allows us to keep the semantics of extensional expressions simpler. The philosophy we follow is that we will only move to the intensional sub-machinery when triggered by an expression that creates a non-extensional context. As the exercise just showed, this is more a matter of taste than a deep scientific decision.

1.3.2 Why Talk about Other Worlds?

Why would natural language bother having such elaborate mechanisms to talk about other possible worlds? While having devices for spatial and temporal displacement (talking about Hamburg or what happened yesterday) seems eminently reasonable, talking about worlds other than the actual world seems only suitable for poets and the like. So, why?

The solution to this puzzle lies in a fact that our current semantics of the shifter *in the world of Sherlock Holmes* does not yet accurately capture: modal sentences have empirical content, they make CONTINGENT claims, claims that are true or false depending on the circumstances in the actual world.

Our example sentence *In the world of Sherlock Holmes, a famous detective lives at 221 Baker Street* is true in this world but it could easily have been false. There is no reason why Sir Arthur Conan Doyle could not have decided to locate Holmes’ abode on Abbey Road.

To see that our semantics does not yet capture this fact, notice that in the semantics we gave for *in the world of Sherlock Holmes*:

- (25) $\llbracket \text{in the world of Sherlock Holmes} \rrbracket^{w,g} =$
 $\lambda p_{\langle s,t \rangle}. \text{the world } w' \text{ as it is described in the Sherlock Holmes stories}$
 $\text{is such that } p(w') = 1.$

there is no occurrence of w on the right hand side. This means that the truth-conditions for sentences with this shifter are world-independent. In other words, they are predicted to make non-contingent claims that are either true whatever or false whatever. This needs to be fixed.

The fix is obvious: what matters to the truth of our sentence is the content of the Sherlock Holmes stories as they are in the evaluation world. So, we need the following semantics for our shifter:

- (26) $\llbracket \text{in the world of Sherlock Holmes} \rrbracket^{w,g} =$
 $\lambda p_{\langle s,t \rangle}. \text{the world } w' \text{ as it is described in the Sherlock Holmes stories}$
 $\text{in } w \text{ is such that } p(w') = 1.$

We see now that sentences with this shifter do make a claim about the evaluation world: namely, that the Sherlock Holmes stories as they are in the evaluation world describe a world in which such-and-such is true. So, what is happening is that although it appears at first as if modal statements concern other possible worlds and thus couldn't really be very informative, they actually only talk about certain possible worlds, those that stand in some relation to what is going on at the ground level in the actual world. As a crude analogy, consider:

- (27) My grandmother is sick.

At one level this is a claim about my grandmother. But it is also a claim about me: namely that I have a grandmother who is sick. Thus it is with modal statements. They talk about possible worlds that stand in a certain relation to the actual world and thus they make claims about the actual world, albeit slightly indirectly.

1.3.3 The Worlds of Sherlock Holmes

So far, we have played along with colloquial usage in talking of *the* world of Sherlock Holmes. But it is important to realize that this is sloppy talk. Lewis [52] writes:

[I]t will not do to follow ordinary language to the extent of supposing that we can somehow single out a single one of the worlds [as the one described by the stories]. Is the world of Sherlock Holmes a world where Holmes has an even or an odd number of hairs on his head at the moment when he first meets Watson? What is Inspector Lestrade's blood type? It is absurd to suppose that these questions about the world of Sherlock Holmes have answers. The best expla-

nation of that is that the worlds of Sherlock Holmes are plural, and the questions have different answers at different ones.

The usual move at this point is to talk about the set of worlds “COMPATIBLE WITH the (content of) Sherlock Holmes stories in w ”. We imagine that we ask of each possible world whether what is going on in it is compatible with the stories as they were written in our world. Worlds where Holmes lives on Abbey Road are not compatible. Some worlds where he lives at 221B Baker Street are compatible (again not all, because in some such worlds he is not a famous detective but an obscure violinist). Among the worlds compatible with the stories are ones where he has an even number of hairs on his head at the moment when he first meets Watson and there are others where he has an odd number of hairs at that moment.

What the operator *in the world of Sherlock Holmes* expresses is that its complement is true throughout the worlds compatible with the stories. In other words, the operator *universally quantifies* over the compatible worlds. Our next iteration of the semantics for the operator is therefore this:

$$(28) \quad \llbracket \text{in the world of Sherlock Holmes} \rrbracket^{w,g} = \\ \lambda p_{\langle s,t \rangle}. \forall w' \text{ compatible with the Sherlock Holmes stories in } w: \\ p(w') = 1.$$

This is where we will leave things. There is more to be said about fiction operators like *in the world of Sherlock Holmes*, but we will just refer to you to the relevant literature. In particular, one might want to make sense of Lewis’ idea that a special treatment is needed for cases where the sentence makes a claim about things that are left open by the fiction (no truth-value, perhaps?). One also needs to figure out how to deal with cases where the fiction is internally inconsistent. In any case, we’re done with this kind of operator.

In the following chapters, we will apply what we have learned here to attitude predicates, modals, and conditionals.

Supplemental Readings

There is considerable overlap between this chapter and Chapter 12 of Heim & Kratzer’s textbook:

HEIM, Irene & KRATZER, Angelika: 1998. *Semantics in Generative Grammar*. Blackwell.

Here, we approach intensional semantics from a different angle. It would probably be beneficial if you read H&K’s Chapter 12 in addition to this chapter and if you did the exercises in there.

Come to think of it, some other ancillary reading is also recommended. You may want to look at relevant chapters in other textbooks:

DOWTY, David, WALL, Robert, & PETERS, Stanley: 1981. *Introduction to Montague Semantics*. Kluwer. [Chapters 5 & 6].

GAMUT, L. T. F.: 1991. *Logic, Language, and Meaning*. Chicago University Press. [Volume II: Intensional Logic and Logical Grammar].

CHIERCHIA, Gennaro & MCCONNELL-GINET, Sally: 2000. *Meaning and Grammar: An Introduction to Semantics (2nd Edition)*. MIT Press. [Chapter 5: Intensionality].

An encyclopedia article by Perry on possible worlds semantics:

PERRY, John R.: 1998. "Semantics, possible worlds." In E. Craig (Editor) *Routledge Encyclopedia of Philosophy*. London: Routledge. URL <http://www.rep.routledge.com/article/U039>. Preprint <http://www-csli.stanford.edu/~john/PHILPAPERS/posswld.pdf>.

An influential philosophical works on the metaphysics and uses of possible worlds:

KRIPKE, Saul: 1980. *Naming and Necessity*. Blackwell.

LEWIS, David: 1986. *On the Plurality of Worlds*. Oxford: Blackwell.

An interesting paper on the origins of the modern possible worlds semantics for modal logic:

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

A personal history of formal semantics:

PARTEE, Barbara H.: 2003. "Reflections of a Formal Semanticist." In *Compositionality in Formal Semantics: Selected Papers*. Blackwell. URL <http://www.blackwellpublishing.com/book.asp?ref=1405109343>.

A must read for students who plan to go on to becoming specialists in semantics, together with a handbook article putting it in perspective:

MONTAGUE, Richard: 1973. "The Proper Treatment of Quantification in Ordinary English." In Jaako Hintikka, Julius Moravcsik, & Patrick Suppes (Editors) *Approaches to Natural Language*, pages 221–242. Reidel. Reprinted in Portner & Partee [66], pp. 17–34.

PARTEE, Barbara H. & HENDRIKS, Herman L.W.: 1997. "Montague Grammar." In Johan van Benthem & Alice ter Meulen (Editors) *Handbook of Logic and Language*, pages 5–91. Amsterdam: Elsevier.

Finally, to learn more about discourse about fiction, read Lewis:

LEWIS, David: 1978. "Truth in Fiction." *American Philosophical Quarterly*, 15: 37–46. Reprinted with postscripts in Lewis [54], pp. 261–280.

A recent reconsideration:

BONOMI, Andrea & ZUCCHI, Sandro: 2003. "A Pragmatic Framework for Truth in Fiction." *Dialectica*, 57(2): 103–120. Preprint <http://filosofia.dipafilo.unimi.it/~zucchi/NuoviFile/Bonomipdf.zip>.

Last year, there was an entry on my blog with comments from readers about indeterminacies in fiction:

Inconsistencies in fictions and elsewhere are discussed in:

VARZI, Achille: 1997. "Inconsistency without Contradiction." *Notre Dame Journal of Formal Logic*, 38(4): 621–638. Preprint http://www.columbia.edu/~av72/papers/Ndjfl_1997.pdf.

LEWIS, David: 1982. "Logic for Equivocators." *Noûs*, 16: 431–441. Reprinted in Lewis [56: pp. 97–110].

— THIS PAGE INTENTIONALLY LEFT BLANK —

CHAPTER 2

PROPOSITIONAL ATTITUDES

With the basic framework in place, we now proceed to analyze a number of intensional constructions. We start with the basic possible worlds semantics for propositional attitude ascriptions. We talk briefly about the formal properties of accessibility relations.

Contents

| | | |
|-------|-------------------------|----|
| 2.1 | Hintikka's Idea | 17 |
| 2.2 | Accessibility Relations | 20 |
| 2.2.1 | Reflexivity | 20 |
| 2.2.2 | Transitivity | 21 |
| 2.2.3 | Symmetry | 21 |
| 2.3 | A Note on Shortcomings | 22 |
| | Supplemental Readings | 22 |

2.1 Hintikka's Idea

Expressions like *believe*, *know*, *doubt*, *expect*, *regret*, and so on are usually said to describe PROPOSITIONAL ATTITUDES. The idea is that they express relations between individuals (the attitude holder) and propositions (intensions of sentences).

The simple idea is that *George believes that Henry is a spy* claims that George believes of the proposition that Henry is a spy that it is true. Note that for the attitude ascription to be true it does not have to hold that Henry is actually a spy.

We might want to be inspired by the colloquial phrase “in the world according to George” and say that *George believes that Henry is a spy* is true iff in the world according to George's beliefs, Henry is a spy. We immediately recall from

the previous chapter that we need to fix this idea up by making space for multiple worlds compatible with George's beliefs and by tying the truth-conditions to contingent facts about the evaluation world. That is, what George believes is different in different possible worlds.

The following lexical entry thus offers itself:

- (29) $\llbracket \text{believe} \rrbracket^{w,g} =$
 $\lambda p_{\langle s,t \rangle} \cdot \lambda x. \forall w' \text{ compatible with } x\text{'s beliefs in } w: p(w') = 1.$

What is going on in this semantics? We conceive of George's beliefs as a state of his mind about whose internal structure we will remain agnostic, a matter left to other cognitive scientists. What we require of it is that it embody opinions about what the world he is located in looks like. His beliefs, in other words, if confronted with a particular possible world w' will determine whether that world may or may not be the world as they think it is. What we are asking of George's mental state is whether anything, any state of affairs, any event, etc. in w' is in contradiction with something that George believes. If not, then w' is compatible with George's beliefs. For all George believes, w' may well be the world where he lives. Many worlds will pass this criterion, just consider as one factor that George is unlikely to have any precise opinions about the number of leaves on the tree in front of my house. George's belief system determines a set of worlds compatible with his beliefs: those worlds that are viable candidates for being the actual world, as far as his belief system is concerned.

Now, George believes a proposition iff that proposition is true in all of the worlds compatible with his beliefs. If there is just one world compatible with his beliefs where the proposition is not true, that means that he considers it possible that the proposition is not true. In such a case, we can't say that he believes the proposition.

Here is the same story in the words of Hintikka [33], the source for this semantics for propositional attitudes:

My basic assumption (slightly simplified) is that an attribution of any propositional attitude to the person in question involves a division of all the possible worlds (...) into two classes: into those possible worlds which are in accordance with the attitude in question and into those which are incompatible with it. The meaning of the division in the case of such attitudes as knowledge, belief, memory, perception, hope, wish, striving, desire, etc. is clear enough. For instance, if what we are speaking of are (say) a 's memories, then these possible worlds are all the possible worlds compatible with everything he remembers. [...]

How are these informal observations to be incorporated into a more explicit semantical theory? According to what I have said, understanding attributions of the propositional attitude in question

(...) means being able to make a distinction between two kinds of possible worlds, according to whether they are compatible with the relevant attitudes of the person in question. The semantical counterpart to this is of course a function which to a given individual person assigns a set of possible worlds.

However, a minor complication is in order here. Of course, the person in question may himself have different attitudes in the different worlds we are considering. Hence this function in effect becomes a relation which to a given individual and to a given possible world μ associates a number of possible worlds which we shall call the *ALTERNATIVES* to μ . The relation will be called the *alternativeness* relation. (For different propositional attitudes, we have to consider different alternativeness relations.)

EXERCISE 2.1: Let's adopt Hintikka's idea that we can use a function that maps x and w into the set of worlds w' compatible with what x believes in w . Call this function \mathcal{F} . That is,

$$(30) \quad \mathcal{F} = \lambda x. \lambda w. \{w' : w' \text{ is compatible with what } x \text{ believes in } w\}.$$

Using this notation, our lexical entry for *believe* would look as follows:

$$(31) \quad \llbracket \text{believe} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \lambda x. \mathcal{F}(x)(w) \subseteq p.$$

We are here indulging in the usual sloppiness in treating p both as a function from worlds to truth-values and as the set characterized by that function.

Here now are two "alternatives" for the semantics of *believe*:

$$(32) \quad \text{ATTEMPT 1 (VERY WRONG)} \\ \llbracket \text{believe} \rrbracket^{w,g} = \lambda p \in D_{\langle s,t \rangle}. [\lambda x \in D. p = \mathcal{F}(x)(w)].$$

$$(33) \quad \text{ATTEMPT 2 (ALSO VERY WRONG)} \\ \llbracket \text{believe} \rrbracket^{w,g} = \lambda p \in D_{\langle s,t \rangle}. [\lambda x \in D. p \cap \mathcal{F}(x)(w) \neq \emptyset].$$

Explain why these do not adequately capture the meaning of *believe*. \square

We can also think of belief states as being represented by a function \mathcal{P} , which maps an individual and a world into a set of propositions. From there, we could calculate the set of worlds compatible with an individual x 's beliefs in world w by retrieving the set of those possible worlds in which all of the propositions in $\mathcal{P}(x)(w)$ are true: $\{w' : \forall p \in \mathcal{P}(x)(w) : p(w') = 1\}$, which in set talk is simply the big intersection of all the propositions in the set: $\cap \mathcal{P}(x)(w)$. With this notation, our lexical entry would be:

$$(34) \quad \llbracket \text{believe} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \lambda x. \cap \mathcal{P}(x)(w) \subseteq p.$$

EXERCISE 2.2: Imagine that our individual x forms a new opinion. Imagine that we model this by adding a new proposition p to the pool of opinions. So, $\mathcal{P}(x)(w)$ now contains one further element. There are now more opinions. What happens to the set of worlds compatible with x 's beliefs? Does it get bigger or smaller? Is the new set a subset or superset of the previous set of compatible worlds? \square

2.2 Accessibility Relations

Another way of reformulating Hintikka's semantics for propositional attitudes is via the notion of an ACCESSIBILITY RELATION. We talk of a world w' being accessible from w . Each attitude can be associated with such an accessibility relation. For example, we can introduce the relation $w\mathcal{R}_a w'$ which holds iff w' is compatible with a 's belief state in w . We have then yet another equivalent way of specifying the lexical entry for *believe*:

$$(35) \quad \llbracket \text{believe} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \lambda x. \forall w' : w\mathcal{R}_a w' \rightarrow p(w') = \mathbf{I}.$$

It is profitable to think of different attitudes (belief, knowledge, hope, regret, memory, ...) as corresponding to different accessibility relations. Recall that the linguistic study of determiners benefitted quite a bit from an investigation of the formal properties of the relations between sets of individuals that determiners express. We can do the same thing here and ask about the formal properties of the accessibility relation associated with belief versus the one associated with knowledge, etc. The obvious properties to think about are reflexivity, transitivity, and symmetry.

2.2.1 Reflexivity

Recall that a relation is reflexive iff for any object in the domain of the relation we know that the relation holds between that object and itself. Which accessibility relations are reflexive? Take knowledge:

$$(36) \quad w\mathcal{R}_x w' \text{ iff } w' \text{ is compatible with what } x \text{ knows in } w.$$

We are asking whether for any given possible world w , we know that \mathcal{R}_x holds between w and w itself. It will hold if w is a world that is compatible with what we know in w . And clearly that must be so. Take our body of knowledge in w . The concept of knowledge crucially contains the concept of truth: what we know must be true. So if in w we know that something is the case then it must be the case in w . So, w must be compatible with all we know in w . \mathcal{R}_x is reflexive.

Now, if an attitude X corresponds to a reflexive accessibility relation, then we can conclude from aXs *that* p being true in w that p is true in w . This property of an attitude predicate is often called **VERIDICALITY**. It is to be distinguished from **FACTIVITY**, which is a property of attitudes which *presuppose* – rather than (merely) entail – the truth of their complement.

If we consider a relation \mathcal{R}'_x pairing with a world w those worlds w' which are compatible with what x *believes* in w , we no longer have reflexivity: belief is not a veridical attitude. It is easy to have false beliefs, which means that the actual world is not in fact compatible with one's beliefs, which contradicts reflexivity.

2.2.2 Transitivity

[to be written]

2.2.3 Symmetry

What would the consequences be if the accessibility relation were symmetric? Symmetry of the accessibility relation \mathcal{R} implies the validity of the following principle:

$$(37) \quad \text{Brouwer's Axiom:} \\ \forall p \forall w : w \in p \rightarrow \left[\forall w' [w \mathcal{R} w' \rightarrow \exists w'' [w' \mathcal{R} w'' \& w'' \in p]] \right]$$

Here's the reasoning: Suppose p is true in w . Pick some arbitrary accessible world w' , i.e. $w \mathcal{R} w'$. Since \mathcal{R} is assumed to be symmetric, we then have $w' \mathcal{R} w$ as well. By assumption, p is true in w , and since w is accessible from w' , this means that p is true in a world accessible from w' . In other words, $\exists w'' [w' \mathcal{R} w'' \& w'' \in p]$. Since p and w were arbitrary, and w' was an arbitrary world accessible from w , this establishes (37).

To see whether a particular kind of attitude is based on a symmetric accessibility relation, we can ask whether Brouwer's Axiom is intuitively valid with respect to this attitude. If it is not valid, this shows that the accessibility relation can't be symmetric.

In the case of a knowledge-based accessibility relation (epistemic accessibility), one can argue in this way that *symmetry does not hold*:¹

The symmetry condition would imply that if something is true, then you know that it is compatible with your knowledge (Brouwer's Axiom). This will be violated by any case in which your beliefs are consistent, but mistaken. Suppose that while p is in fact true, you feel certain that it is false, and so think that you know that it is

¹ Thanks to Bob Stalnaker (pc to Kai von Fintel) for help with the following reasoning.

false. Since you think you know this, it is compatible with your knowledge that you know it. (Since we are assuming you are consistent, you can't both believe that you know it, and know that you do not). So it is compatible with your knowledge that you know that *not* p. Equivalently²: you don't know that you don't know that *not* p. Equivalently: you don't know that it's compatible with your knowledge that p. But by Brouwer's Axiom, since p is true, you would have to know that it's compatible with your knowledge that p. So if Brouwer's Axiom held, there would be a contradiction. So Brouwer's Axiom doesn't hold here, which shows that epistemic accessibility is not symmetric.

Game theorists and theoretical computer scientists who traffic in logics of knowledge often assume that the accessibility relation for knowledge is an equivalence relation (reflexive, symmetric, and transitive). But this is appropriate only if one abstracts away from any error, in effect assuming that belief and knowledge coincide.

2.3 A Note on Shortcomings

[... to be written ... stuff about HYPERINTENSIONALITY]

Supplemental Readings

We will come back to propositional attitudes and especially the scope of noun phrases with respect to them, including the infamous DE DICTO-DE RE distinction. See Chapters 6 and 7.

Further connections between mathematical properties of accessibility relations and logical properties of various notions of necessity and possibility are studied extensively in modal logic:

HUGHES, George & CRESWELL, Max: 1996. *A New Introduction to Modal Logic*. Routledge London.

GARSON, James: Winter 2003. "Modal Logic." In Edward N. Zalta (Editor) *The Stanford Encyclopedia of Philosophy*. URL <http://plato.stanford.edu/archives/win2003/entries/logic-modal/>, especially section 7 and 8, "Modal Axioms and Conditions on Frames", "Map of the Relationships between Modal Logics".

² This and the following step rely on the duality of necessity and possibility: q is compatible with your knowledge iff you don't know that *not* q.

A thorough discussion of the possible worlds theory of attitudes can be found in Bob Stalnaker's work:

STALNAKER, Robert: 1984. *Inquiry*. MIT Press.

STALNAKER, Robert: 1999. *Context and Content*. Oxford: Oxford University Press.

Linguistic work on attitudes has often been concerned with various co-occurrence patterns, particularly which moods (indicative or subjunctive or infinitive) occur in the complement and whether negative polarity items are licensed in the complement.

Mood licensing:

PORTNER, Paul: 1997. "The Semantics of Mood, Complementation, and Conversational Force." *Natural Language Semantics*, 5(2): 167–212. doi:10.1023/A:1000000000000

NPI-Licensing:

KADMON, Nirit & LANDMAN, Fred: 1993. "Any." *Linguistics & Philosophy*, 16: 353–422.

VON FINTEL, Kai: 1999. "NPI Licensing, Strawson Entailment, and Context Dependency." *Journal of Semantics*, 16(2): 97–148. URL http://www3.oup.co.uk/semant/hdb/Volume_16/Issue_02/160097.sgm.abs.html. Preprint: <http://web.mit.edu/fintel/www/npi.pdf>.

GIANNAKIDOU, Anastasia: 1999. "Affective Dependencies." *Linguistics & Philosophy*, 22(4): 367–421. doi:10.1023/A:1005492130684.

Neg-Raising, cf. ongoing work by Jon Gajewski on his MIT dissertation.

Interesting work has also been done on presupposition projection in attitude contexts, but this can only be appreciated after you have studied theories of presupposition and context change.

HEIM, Irene: 1992. "Presupposition Projection and the Semantics of Attitude Verbs." *Journal of Semantics*, 9: 183–221.

GEURTS, Bart: 1998. "Presuppositions and Anaphors in Attitude Contexts." *Linguistics & Philosophy*, 21(6): 545–601. doi:10.1023/A:1005481821597.

— THIS PAGE INTENTIONALLY LEFT BLANK —

We turn to modal auxiliaries and related constructions. The main difference from attitude constructions is that their semantics is more context-dependent. Otherwise, we are still quantifying over possible worlds.

Contents

| | | |
|-------|---|----|
| 3.1 | The Quantificational Theory of Modality | 25 |
| 3.1.1 | Syntactic Assumptions | 26 |
| 3.1.2 | Quantification over Possible Worlds | 26 |
| 3.2 | Flavors of Modality | 28 |
| 3.2.1 | Contingency | 28 |
| 3.2.2 | Epistemic vs. Circumstantial Modality | 32 |
| 3.2.3 | Contingency Again | 33 |
| 3.2.4 | Iteration | 35 |
| 3.2.5 | A technical variant of the analysis | 36 |
| 3.3 | Kratzer's Conversational Backgrounds | 37 |
| | Supplemental Readings | 40 |

3.1 The Quantificational Theory of Modality

We will now be looking at modal auxiliaries like *may*, *must*, *can*, *have to*, etc. Most of what we say here should carry over straightforwardly to modal adverbs like *maybe*, *possibly*, *certainly*, etc. We will make certain syntactic assumptions, which make our work easier but which leave aside many questions that at some point deserve to be addressed.

3.1.1 Syntactic Assumptions

We will assume, at least for the time being, that a modal like *may* is a RAISING predicate (rather than a CONTROL predicate), i.e., its subject is not its own argument, but has been moved from the subject-position of its infinitival complement.¹ So, we are dealing with the following kind of structure:

- (38) a. Ann may be smart.
 b. [Ann [λ_t [may [t_t be smart]]]]

Actually, we will be working here with the even simpler structure below, in which the subject has been reconstructed to its lowest trace position. (E.g., these could be generated by deleting all but the lowest copy in the movement chain.²) We will be able to prove that movement of a name or pronoun never affects truth-conditions, so at any rate the interpretation of the structure in (38b) would be the same as of (39). As a matter of convenience, then, we will take the reconstructed structures, which allow us to abstract away from the (here irrelevant) mechanics of variable binding.

- (39) may [Ann be smart]

So, for now at least, we are assuming that modals are expressions that take a full sentence as their semantic argument.³ Now then, what do modals mean?

3.1.2 Quantification over Possible Worlds

The basic idea of the possible worlds semantics for modal expressions is that they are quantifiers over possible worlds. Toy lexical entries for *must* and *may*, for example, would look like this:

- (40) $\llbracket \text{must} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \forall w' : p(w') = 1.$

- (41) $\llbracket \text{may} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \exists w' : p(w') = 1.$

This analysis is too crude (in particular, notice that it would make modal sentences non-contingent – there is no occurrence of the evaluation world on the right hand side!). But it does already have some desirable consequences that we will seek to preserve through all subsequent refinements. It correctly predicts a number of intuitive judgments about the logical relations between *must* and

¹ The issue of raising vs. control will be taken up later. If you are eager to get started on it, read Sabine's handout on the issue:

² We will talk about reconstruction in more detail later.

³ We will assume that even though *Ann be smart* is a non-finite sentence, this will not have any effect on its semantic type, which is that of a sentence, which in turn means that its semantic value is a truth-value. This is hopefully independent of the (interesting) fact that *Ann be smart* on its own cannot be used to make a truth-evaluable assertion.

may and among various combinations of these items and negations. To start with some elementary facts, we feel that *must* ϕ entails *may* ϕ , but not vice versa:

- (42) You must stay.
Therefore, you may stay. VALID
- (43) You may stay.
Therefore, you must stay. INVALID
- (44) a. You may stay, but it is not the case that you must stay.⁴
b. You may stay, but you don't have to stay.
CONSISTENT

We judge *must* ϕ incompatible with its "inner negation" *must* [*not* ϕ], but find *may* ϕ and *may* [*not* ϕ] entirely compatible:

- (45) You must stay, and/but also, you must leave. (leave = not stay).
CONTRADICTION
- (46) You may stay, but also, you may leave.
CONSISTENT

We also judge that in each pair below, the (a)-sentence and the (b)-sentences say the same thing.

- (47) a. You must stay.
b. It is not the case that you may leave.
You aren't allowed to leave.
(You may not leave.)⁵
(You can't leave.)
- (48) a. You may stay.
b. It is not the case that you must leave.
You don't have to leave.

4 The somewhat stilted *it is not the case*-construction is used in to make certain that negation takes scope over *must*. When modal auxiliaries and negation are together in the auxiliary complex of the same clause, their relative scope seems not to be transparently encoded in the surface order; specifically, the scope order is not reliably negation \succ modal. (Think about examples with *mustn't*, *can't*, *shouldn't*, *may not* etc. What's going on here? This is an interesting topic which we must set aside for now. See the references at the end of the chapter for relevant work.) With modal *main* verbs (such as *have to*), this complication doesn't arise; they are consistently inside the scope of clause-mate auxiliary negation. Therefore we can use (b) to (unambiguously) express the same scope order as (a), without having to resort to a biclausal structure.

5 The parenthesized variants of the (b)-sentences are pertinent here only to the extent that we can be certain that negation scopes over the modal. In these examples, apparently it does, but as we remarked above, this cannot be taken for granted in all structures of this form.

You don't need to leave.
(You needn't leave.)

Given that *stay* and *leave* are each other's negations (i.e. $\llbracket \text{leave} \rrbracket^{w,g} = \llbracket \text{not stay} \rrbracket^{w,g}$, and $\llbracket \text{stay} \rrbracket^{w,g} = \llbracket \text{not leave} \rrbracket^{w,g}$), the LF-structures of these equivalent pairs of sentences can be seen to instantiate the following schemata:⁶

- (49) a. $\text{must } \phi \equiv \text{not } [\text{may } [\text{not } \phi]]$
 b. $\text{must } [\text{not } \psi] \equiv \text{not } [\text{may } \psi]$
- (50) a. $\text{may } \phi \equiv \text{not } [\text{must } [\text{not } \phi]]$
 b. $\text{may } [\text{not } \psi] \equiv \text{not } [\text{must } \psi]$

Our present analysis of *must*, *have-to*, ... as universal quantifiers and of *may*, *can*, ... as existential quantifiers straightforwardly predicts all of the above judgments, as you can easily prove.

- (51) a. $\forall x \phi \equiv \neg \exists \neg \phi$
 b. $\forall x \neg \phi \equiv \neg \exists x \phi$
- (52) a. $\exists x \phi \equiv \neg \forall x \neg \phi$
 b. $\exists x \neg \phi \equiv \neg \forall x \phi$

3.2 Flavors of Modality

3.2.1 Contingency

We already said that the semantics we started with is too simple-minded. In particular, we have no dependency on the evaluation world, which would make modal statements non-contingent. This is not correct.

If one says *It may be snowing in Cambridge*, that may well be part of useful, practical advice about what to wear on your upcoming trip to Cambridge. It may be true or it may be false. The sentence seems true if said in the dead of winter when we have already heard about a Nor'Easter that is sweeping across New England. The sentence seems false if said by a clueless Australian acquaintance of ours in July.

The contingency of modal claims is not captured by our current semantics. All the *may*-sentence would claim under that semantics is that there is some possible world where it is snowing in Cambridge. And surely, once you have read Lewis' quote in Chapter 1, where he asserts the existence of possible worlds with different physical constants than we enjoy here, you must admit that there have to be such worlds even if it is July. The problem is that in our semantics, repeated here

⁶ In logicians' jargon, *must* and *may* behave as DUALS of each other. For definitions of "dual", see Barwise & Cooper [1:197] or Gamut [26:vol.2,238]

$$(53) \quad \llbracket \text{may} \rrbracket^{w,g} = \lambda p_{\langle s,t \rangle}. \exists w' : p(w') = 1.$$

there is no occurrence of w on the right hand side. This means that the truth-conditions for *may*-sentences are world-independent. In other words, they make non-contingent claims that are either true whatever or false whatever, and because of the plenitude of possible worlds they are more likely to be true than false. This needs to be fixed. But how?

Well, what makes *it may be snowing in Cambridge* seem true when we know about a Nor'Easter over New England? What makes it seem false when we know that it is summer in New England? The idea is that we only consider possible worlds COMPATIBLE WITH THE EVIDENCE AVAILABLE TO US. And since what evidence is available to us differs from world to world, so will the truth of a *may*-statement.

$$(54) \quad \llbracket \text{may} \rrbracket^{w,g} = \lambda p. \exists w' \text{ compatible with the evidence in } w : p(w') = 1.^7$$

$$(55) \quad \llbracket \text{must} \rrbracket^{w,g} = \lambda p. \forall w' \text{ compatible with the evidence in } w : p(w') = 1.$$

Let us consider a different example:

$$(56) \quad \text{You have to be quiet.}$$

Imagine this sentence being said based on the house rules of the particular dormitory you live in. Again, this is a sentence that could be true or could be false. Why do we feel that this is a contingent assertion? Well, the house rules can be different from one world to the next, and so we might be unsure or mistaken about what they are. In one possible world, they say that all noise must stop at 11pm, in another world they say that all noise must stop at 10pm. Suppose we know that it is 10:30 now, and that the dorm we are in has either one or the other of these two rules, but we have forgotten which. Then, for all we know, *you have to be quiet* may be true or it may be false. This suggests a lexical entry along these lines:

$$(57) \quad \llbracket \text{have-to} \rrbracket^{w,g} = \lambda p. \forall w' \text{ compatible with the rules in } w : p(w') = 1.$$

Again, we are tying the modal statement about other worlds down to certain worlds that stand in a certain relation to actual world: those worlds where the rules as they are here are obeyed.

A note of caution: it is very important to realize that the worlds compatible with the rules as they are in w are those worlds where nothing happens that violates any of the w -rules. This is not at all the same as saying that the worlds compatible with the rules in w are those worlds where the same rules are in force. Usually, the rules do not care what the rules are, unless the rules contain

⁷ From now on, we will leave off type-specifications such as that p has to be of type $\langle s, t \rangle$, whenever it is obvious what they should be and when saving space is aesthetically called for.

some kind of meta-statement to the effect that the rules have to be the way they are, i.e. that the rules cannot be changed. So, in fact, a world w' in which nothing happens that violates the rules as they are in w but where the rules are quite different and in fact what happens violates the rules as they are in w' is nevertheless a world compatible with the rules in w . For example, imagine that the only relevant rule in w is that students go to bed before midnight. Take a world w' where a particular student goes to bed at 11:30 pm but where the rules are different and say that students have to go to bed before 11 pm. Such a world w' is compatible with the rules in w (but of course not with the rules in w').

Apparently, there are different flavors of modality, varying in what kind of facts in the evaluation world they are sensitive to. The semantics we gave for *must* and *may* above makes them talk about evidence, while the semantics we gave for *have-to* made it talk about rules. But that was just because the examples were hand-picked. In fact, in the dorm scenario we could just as well have said *You must be quiet*. And, vice versa, there is nothing wrong with using *it has to be snowing in Cambridge* based on the evidence we have. In fact, many modal expressions seem to be multiply ambiguous.

Traditional descriptions of modals often distinguish a number of “readings”: EPISTEMIC, DEONTIC, ABILITY, CIRCUMSTANTIAL, DYNAMIC, (Beyond “epistemic” and “deontic,” there is a great deal of terminological variety. Sometimes all non-epistemic readings are grouped together under the term *ROOT*.) Here are some initial illustrations.

(58) EPISTEMIC MODALITY

A: Where is John?

B: I don't know. He *may* be at home.

(59) DEONTIC MODALITY

A: Am I allowed to stay over at Janet's house?

B: No, but you *may* bring her here for dinner.

(60) CIRCUMSTANTIAL/DYNAMIC MODALITY

A: I will plant the rhododendron here.

B: That's not a good idea. It *can grow very tall*.

How are *may* and *can* interpreted in each of these examples? What do the interpretations have in common, and where do they differ?

In all three examples, the modal makes an existentially quantified claim about possible worlds. This is usually called the *MODAL FORCE* of the claim. What differs is what worlds are quantified over. In *EPISTEMIC* modal sentences, we quantify over worlds compatible with the evidence we have. In *DEONTIC* modal sentences, we quantify over worlds compatible with the rules and/or regulations. And in the *CIRCUMSTANTIAL* modal sentence, we quantify over the set

of worlds which conform to the laws of nature (in particular, plant biology). What speaker B in (60) is saying, then, is that there are some worlds conforming to the laws of nature in which this rhododendron grows very tall. (Or is this another instance of an epistemic reading? See below for discussion of the distinction between circumstantial readings and epistemic ones.)

How can we account for this variety of readings? One way would be to write a host of lexical entries, basically treating this as a kind of (more or less principled) ambiguity. Another way, which is preferred by many people, is to treat this as a case of context-dependency, as argued in seminal work by Kratzer [43, 44, 45, 47].

According to Kratzer, what a modal brings with it intrinsically is just a modal force, that is, whether it is an existential (possibility) modal or a universal (necessity) modal. What worlds it quantifies over is determined by context. In essence, the context has to supply a restriction to the quantifier. How can we implement this idea?

We encountered context-dependency before when we talked about pronouns and their referential (and E-Type) readings (H&K, chapters 9–11). We treated referential pronouns as free variables, appealing to a general principle that free variables in an LF need to be supplied with values from the utterance context. If we want to describe the context-dependency of modals in a technically analogous fashion, we can think of their LF-representations as incorporating or sub-categorizing for a kind of invisible pronoun, a free variable that stands for a set of possible worlds. So we posit LF-structures like this:

$$(61) \quad [I' \ [I \text{ must } p_{\langle s, t \rangle}] \ [_{VP} \text{ you quiet}]]$$

$p_{\langle s, t \rangle}$ here is a variable over (characteristic functions of) sets of worlds, which – like all free variables – needs to receive a value from the utterance context. Possible values include: the set of worlds compatible with the speaker's current knowledge; the set of worlds in which everyone obeys all the house rules of a certain dormitory; and many others. The denotation of the modal itself now has to be of type $\langle st, \langle st, t \rangle \rangle$ rather than $\langle st, t \rangle$, thus it will be more like a quantificational determiner rather than a complete generalized quantifier. Only after the modal has been combined with its covert restrictor do we obtain a value of type $\langle st, t \rangle$.

$$(62) \quad \begin{aligned} \text{a.} \quad & \llbracket \text{must} \rrbracket^{w, g} = \llbracket \text{have-to} \rrbracket^{w, g} = \llbracket \text{need-to} \rrbracket^{w, g} = \dots = \\ & \lambda p \in D_{\langle s, t \rangle}. \lambda q \in D_{\langle s, t \rangle}. \forall w \in W [p(w) = 1 \rightarrow q(w) = 1] \\ & \hspace{15em} (\text{in set talk: } p \subseteq q). \\ \text{b.} \quad & \llbracket \text{may} \rrbracket^{w, g} = \llbracket \text{can} \rrbracket^{w, g} = \llbracket \text{be-allowed-to} \rrbracket^{w, g} = \dots = \\ & \lambda p \in D_{\langle s, t \rangle}. \lambda q \in D_{\langle s, t \rangle}. \exists w \in W [p(w) = 1 \ \& \ q(w) = 1] \\ & \hspace{15em} (\text{in set talk: } p \cap q \neq \emptyset). \end{aligned}$$

On this approach, the epistemic, deontic, etc. “readings” of individual occur-

rences of modal verbs come about by a combination of two separate things. The lexical semantics of the modal itself encodes just a quantificational force, a *relation* between sets of worlds. This is either the subset-relation (universal quantification; necessity) or the relation of non-disjointness (existential quantification; possibility). The covert variable next to the modal picks up a contextually salient set of worlds, and this functions as the quantifier's restrictor. The labels "epistemic", "deontic", "circumstantial" etc. group together certain conceptually natural classes of possible values for this covert restrictor.

Notice that, strictly speaking, there is not just one deontic reading (for example), but many. A speaker who utters

(63) You have to be quiet.

might mean: 'I want you to be quiet,' (i.e., you are quiet in all those worlds that conform to my preferences). Or she might mean: 'unless you are quiet, you won't succeed in what you are trying to do,' (i.e., you are quiet in all those worlds in which you succeed at your current task). Or she might mean: 'the house rules of this dormitory here demand that you be quiet,' (i.e., you are quiet in all those worlds in which the house rules aren't violated). And so on. So the label "deontic" appears to cover a whole open-ended set of imaginable "readings", and which one is intended and understood on a particular utterance occasion may depend on all sorts of things in the interlocutors' previous conversation and tacit shared assumptions. (And the same goes for the other traditional labels.)

3.2.2 Epistemic vs. Circumstantial Modality

Is it all context-dependency? Or do flavors of modality correspond to all sorts of signals in the structure of sentences? Read the following famous passage from Kratzer and think about how the two sentences with their very different modal meanings differ in structure:

Consider sentences (64) and (65):

(64) Hydrangeas can grow here.

(65) There might be hydrangeas growing here.

The two sentences differ in meaning in a way which is illustrated by the following scenario.

"Hydrangeas"

Suppose I acquire a piece of land in a far away country and discover that soil and climate are very much like at home, where hydrangeas prosper everywhere. Since hydrangeas are my favorite plants, I wonder whether they would grow in this place and inquire about it.

The answer is (64). In such a situation, the proposition expressed by (64) is true. It is true regardless of whether it is or isn't likely that there are already hydrangeas in the country we are considering. All that matters is climate, soil, the special properties of hydrangeas, and the like. Suppose now that the country we are in has never had any contacts whatsoever with Asia or America, and the vegetation is altogether different from ours. Given this evidence, my utterance of (65) would express a false proposition. What counts here is the complete evidence available. And this evidence is not compatible with the existence of hydrangeas.

(64) together with our scenario illustrates the pure CIRCUMSTANTIAL reading of the modal *can*. [...]. (65) together with our scenario illustrates the epistemic reading of modals. [...] circumstantial and epistemic conversational backgrounds involve different kinds of facts. In using an epistemic modal, we are interested in what else may or must be the case in our world given all the evidence available. Using a circumstantial modal, we are interested in the necessities implied by or the possibilities opened up by certain sorts of facts. Epistemic modality is the modality of curious people like historians, detectives, and futurologists. Circumstantial modality is the modality of rational agents like gardeners, architects, and engineers. A historian asks what might have been the case, given all the available facts. An engineer asks what can be done given certain relevant facts.

Consider also the very different prominent meanings of the following two sentences, taken from Kratzer as well:

- (66) a. Cathy can make a pound of cheese out of this can of milk.
 b. Cathy might make a pound of cheese out of this can of milk.

EXERCISE 3.1: Come up with examples of epistemic, deontic, and circumstantial uses of the necessity verb *have to*. Describe the set of worlds that constitutes the understood restrictor in each of your examples. □

3.2.3 Contingency Again

We messed up. If you inspect the context-dependent meanings we have on the table now for our modals, you will see that the right hand sides again do not mention the evaluation world w . Therefore, we will again have the problem of not making contingent claims, indirectly about the actual world. This needs to be fixed. We need a semantics that is both context-dependent and contingent.

The problem, it turns out, is with the idea that the utterance context supplies a *determinate set of worlds* as the restrictor. When I understand that you

meant your use of *must*, in *you must be quiet*, to quantify over the set of worlds in which the house rules of our dorm are obeyed, this does not imply that you and I have to know or agree on which set exactly this is. That depends on what the house rules in our world actually happen to say, and this may be an open question at the current stage of our conversation. What we do agree on, if I have understood your use of *must* in the way that you intended it, is just that it quantifies over *whatever set of worlds it may be* that the house rules pick out.

The technical implementation of this insight requires that we think of the context's contribution not as a set of worlds, but rather as a function which for each world it applies to picks out such a set. For example, it may be the function which, for any world w , yields the set $\{w' : \text{the house rules that are in force in } w \text{ are obeyed in } w'\}$. If we apply this function to a world w_1 , in which the house rules read "no noise after 10 pm", it will yield a set of worlds in which nobody makes noise after 10 pm. If we apply the same function to a world w_2 , in which the house rules read "no noise after 11 pm", it will yield a set of worlds in which nobody makes noise after 11 pm.

Suppose, then, that the covert restrictor of a modal predicate denotes such a function, i.e., its value is of type $\langle s, st \rangle$.

$$(67) \quad [_I \ [_I \text{ must } R_{\langle s, st \rangle}] \ [_{VP} \text{ you quiet}]]$$

And the new lexical entries for *must* and *may* that will fit this new structure are these:

(68) For any $w \in W$:

- a. $\llbracket \text{must} \rrbracket^{w,g} = \llbracket \text{have-to} \rrbracket^{w,g} = \llbracket \text{need-to} \rrbracket^{w,g} = \dots =$
 $\lambda R \in D_{\langle s, st \rangle} \cdot \lambda q \in D_{\langle s, t \rangle} \cdot \forall w' \in W [R(w)(w') = 1 \rightarrow q(w') = 1]$
(in set talk: $(R(w) \subseteq q)$)
- b. $\llbracket \text{may} \rrbracket^{w,g} = \llbracket \text{can} \rrbracket^{w,g} = \llbracket \text{be-allowed-to} \rrbracket^{w,g} = \dots =$
 $\lambda R \in D_{\langle s, st \rangle} \cdot \lambda q \in D_{\langle s, t \rangle} \cdot \exists w' \in W [R(w)(w') = 1 \ \& \ q(w') = 1]$
(in set talk: $(R(w) \cap q \neq \emptyset)$)

Let us see now how this solves the contingency problem.

(69) Let w be a world, and assume that the context supplies an assignment g such that $g(R) = \lambda w. \lambda w'$. the house rules in force in w are obeyed in w'

$$\begin{aligned} \llbracket \text{must } R \text{ you quiet} \rrbracket^{w,g} &= && \text{(IFA)} \\ \llbracket \text{must } R \rrbracket^{w,g} (\lambda w' \llbracket \text{you quiet} \rrbracket^{w'}) &= && \text{(EA)} \\ \llbracket \text{must} \rrbracket^{w,g} (\llbracket R \rrbracket^{w,g}) (\lambda w' \llbracket \text{you quiet} \rrbracket^{w'}) &= && \text{(lex. entries } you, quiet) \\ \llbracket \text{must} \rrbracket^{w,g} (\llbracket R \rrbracket^{w,g}) (\lambda w'. \text{you are quiet in } w') &= && \text{(lex. entry } must) \\ \forall w' \in W : \llbracket R \rrbracket^{w,g}(w)(w') = 1 \rightarrow \text{you are quiet in } w' &= && \text{(pronoun rule)} \\ \forall w' \in W : g(R)(w)(w') = 1 \rightarrow \text{you are quiet in } w' &= && \text{(def. of } g) \end{aligned}$$

$\forall w' \in W$ [the house rules in force in w are obeyed in w'
 \rightarrow you are quiet in w']

As we see in the last line of (69), the truth-value of (67) depends on the evaluation world w .

EXERCISE 3.2: Describe two worlds w_1 and w_2 so that
 $\llbracket \text{must } R \text{ you quiet} \rrbracket^{w_1, g} = 1$ and $\llbracket \text{must } R \text{ you quiet} \rrbracket^{w_2, g} = 0$. \square

EXERCISE 3.3: In analogy to the deontic relation $g(R)$ defined in (69), define an appropriate relation that yields an epistemic reading for a sentence like *You may be quiet*. \square

3.2.4 Iteration

Consider the following example:

(70) You might have to leave.

What does this mean? Under one natural interpretation, we learn that the speaker considers it possible that the addressee is under the obligation to leave. This seems to involve one modal embedded under a higher modal. It appears that this sentence should be true in a world w iff some world w' compatible with what the speaker knows in w is such that every world w'' in which the rules as they are in w' are followed is such that you leave in w'' .

Assume the following LF:

(71) $[_I' [_{\text{might } R_1} [_{\text{VP}} [_{\text{have-to } R_2} [_{\text{IP}} \text{you leave}]]]]]$

Suppose w is the world for which we calculate the truth-value of the whole sentence, and the context maps R_1 to the function which maps w to the set of all those worlds compatible with what is known in w . *might* says that some of those worlds are worlds w' that make the tree below *might* true. Now assume further that the context maps R_2 to the function which assigns to any such world w' the set of all those worlds in which the rules as they are in w' are followed. *have to* says that all of those worlds are worlds w'' in which you leave.

In other words, while it is not known to be the case that you have to leave, for all the speaker knows it might be the case.

EXERCISE 3.4: Describe values for the covert $\langle s, st \rangle$ -variable that are intuitively suitable for the interpretation of the modals in the following sentences:

(72) As far as John's preferences are concerned, you *may* stay with us.

(73) According to the guidelines of the graduate school, every PhD candidate *must* take 9 credit hours outside his/her department.

- (74) John *can* run a mile in 5 minutes.
 (75) This *has* to be the White House.
 (76) This elevator *can* carry up to 3000 pounds.

For some of the sentences, different interpretations are conceivable depending on the circumstances in which they are uttered. You may therefore have to sketch the utterance context you have in mind before describing the accessibility relation. □

EXERCISE 3.5: Collect two naturally occurring examples of modalized sentences (e.g., sentences that you overhear in conversation, or read in a newspaper or novel – not ones that are being used as examples in a linguistics or philosophy paper!), and give definitions of values for the covert $\langle s, st \rangle$ -variable which account for the way in which you actually understood these sentences when you encountered them. (If the appropriate interpretation is not salient for the sentence out of context, include information about the relevant preceding text or non-linguistic background.) □

3.2.5 A technical variant of the analysis

In our account of the contingency of modalized sentences, we adopted lexical entries for the modals that gave them world-dependent extensions of type $\langle \langle s, st \rangle, \langle st, t \rangle \rangle$:

- (77) (repeated from earlier):
 For any $w \in W$: $\llbracket \text{must} \rrbracket^{w,g}$
 $\lambda R \in D_{\langle s, st \rangle}. \lambda q \in D_{\langle s, t \rangle}. \forall w' \in W [R(w)(w') = 1 \rightarrow q(w') = 1]$
 (in set talk: $\lambda R_{\langle s, st \rangle}. \lambda q_{\langle s, t \rangle}. (R(w) \subseteq q)$).

Unfortunately, this treatment somewhat obscures the parallel between the modals and the quantificational determiners, which have world-independent extensions of type $\langle et, \langle et, t \rangle \rangle$.

Let's explore an alternative solution to the contingency problem, which will allow us to stick with the world-independent type- $\langle st, \langle st, t \rangle \rangle$ -extensions that we assumed for the modals at first:

- (78) (repeated from even earlier):
 $\llbracket \text{must} \rrbracket^{w,g} = \lambda p \in D_{\langle s, t \rangle}. \lambda q \in D_{\langle s, t \rangle}. \forall w \in W [p(w) = 1 \rightarrow q(w) = 1]$
 (in set talk: $\lambda p \in D_{\langle s, t \rangle}. \lambda q \in D_{\langle s, t \rangle}. p \subseteq q$).

We posit the following LF-representation:

- (79) $[_I' [_I \text{ must } [_{R_{\langle 4, \langle s, st \rangle \rangle}} w^*]] [_{VP} \text{ you quiet}]]$

What is new here is that the covert restrictor is complex. The first part, $R_{\langle 4, \langle s, st \rangle \rangle}$, is (as before) a free variable of type $\langle s, st \rangle$, which gets assigned an accessibility relation by the context of utterance. The second part is a special terminal symbol which is interpreted as picking out the evaluation world:

(80) For any $w \in W$: $\llbracket w* \rrbracket^{w,g} = w$.⁸

When $R_{\langle 4, \langle s, st \rangle \rangle}$ and w^* combine (by Functional Application), we obtain a constituent whose extension is of type $\langle s, t \rangle$ (a proposition or set of worlds). This is the same type as the extension of the free variable p in the previous proposal, hence suitable to combine with the old entry for *must* (by FA). However, while the extension of p was completely fixed by the variable assignment, and did not vary with the evaluation world, the new complex constituent's extension depends on both the assignment and the world:

(81) For any $w \in W$ and any assignment g :
 $\llbracket R_{\langle 4, \langle s, st \rangle \rangle}(w^*) \rrbracket^{w,g} = g(\langle 4, \langle s, st \rangle \rangle)(w)$.

As a consequence of this, the extensions of the higher nodes I and I' will also vary with the evaluation world, and this is how we capture the fact that (79) is contingent.

Maybe this variant is more appealing. But for the rest of this chapter, we continue to assume the original analysis as presented earlier. In the next chapter on conditionals, we will however make crucial use of this way of doing the semantics for modals. So, make sure you understand what we just proposed.

3.3 Kratzer's Conversational Backgrounds

Angelika Kratzer has some interesting ideas on how accessibility relations are supplied by the context. She argues that what is really floating around in a discourse is a CONVERSATIONAL BACKGROUND. Accessibility relations can be computed from conversational backgrounds (as we shall do here), or one can state the semantics of modals directly in terms of conversational backgrounds (as Kratzer does).

A conversational background is the sort of thing that is identified by phrases like *what the law provides*, *what we know*, etc. Take the phrase *what the law provides*. What the law provides is different from one possible world to another. And what the law provides in a particular world is a *set of propositions*. Likewise, what we know differs from world to world. And what we know in a particular world is a set of propositions. The intension of *what the law provides* is then that function which assigns to every possible world the set of propositions p

⁸ Dowty [13] introduced an analogous symbol to pick out the evaluation *time*. We have chosen the star-notation to allude to this precedent.

such that the law provides in that world that p . Of course, that doesn't mean that p holds in that world itself: the law can be broken. And the intension of *what we know* will be that function which assigns to every possible world the set of propositions we know in that world. Quite generally, conversational backgrounds are functions of type $\langle s, \langle st, t \rangle \rangle$, functions from worlds to (characteristic functions of) sets of propositions.

Now, consider:

(82) (In view of what we know,) Brown must have murdered Smith.

The *in view of*-phrase may explicitly signal the intended conversational background. Or, if the phrase is omitted, we can just infer from other clues in the discourse that such an epistemic conversational background is intended. We will focus on the case of pure context-dependency.

How do we get from a conversational background to an accessibility relation? Take the conversational background at work in (82). It will be the following:

(83) $\lambda w. \lambda p. p$ is one of the propositions that we know in w .

This conversational background will assign to any world w the set of propositions p that in w are known by us. So we have a set of propositions. From that we can get the set of worlds in which all of the propositions in this set are true. These are the worlds that are compatible with everything we know. So, this is how we get an accessibility relation:

(84) For any conversational background f of type $\langle s, \langle st, t \rangle \rangle$, we define the corresponding accessibility relation R_f of type $\langle s, st \rangle$ as follows:
 $R_f := \lambda w. \lambda w'. \forall p [f(w)(p) = 1 \rightarrow p(w') = 1]$.

In words, w' is f -accessible from w iff all propositions p that are assigned by f to w are true in w' .

Kratzer calls those conversational backgrounds that determine the set of accessible worlds MODAL BASES. We can be sloppy and use this term for a number of interrelated concepts:

- (i) the conversational background (type $\langle s, \langle st, t \rangle \rangle$),
- (ii) the set of propositions assigned by the conversational background to a particular world (type $\langle st, t \rangle$),
- (iii) the accessibility relation (type $\langle s, st \rangle$) determined by (i),
- (iv) the set of worlds accessible from a particular world (type $\langle s, t \rangle$).

Kratzer calls a conversational background (modal base) REALISTIC iff it assigns to *any* world a set of propositions that are all true in that world. The modal base *what we know* is realistic, the modal bases *what we believe* and *what we want* are not.

What follows are some (increasingly technical exercises) on conversational backgrounds.

EXERCISE 3.6: Show that a conversational background f is realistic iff the corresponding accessibility relation R_f (defined as in (84)) is reflexive. \square

EXERCISE 3.7: Let us call an accessibility relation TRIVIAL if it makes every world accessible from every world. R is TRIVIAL iff $\forall w \forall w' : w' \in R(w)$. What would the conversational background f have to be like for the accessibility relation R_f to be trivial in this sense? \square

EXERCISE 3.8: The definition in (84) specifies, in effect, a function from $D_{\langle s, \langle st, t \rangle \rangle}$ to $D_{\langle s, st \rangle}$. It maps each function f of type $\langle s, \langle st, t \rangle \rangle$ to a unique function R_f of type $\langle s, st \rangle$. This mapping is not one-to-one, however. Different elements of $D_{\langle s, \langle st, t \rangle \rangle}$ may be mapped to the same value in $D_{\langle s, st \rangle}$.⁹

- Prove this claim. I.e., give an example of two functions f and f' in $D_{\langle s, \langle st, t \rangle \rangle}$ for which (84) determines $R_f = R_{f'}$.
- As you have just proved, if every function of type $\langle s, \langle st, t \rangle \rangle$ qualifies as a ‘conversational background’, then two different conversational backgrounds can collapse into the same accessibility relation. Conceivably, however, if we imposed further restrictions on conversational backgrounds (i.e., conditions by which only a proper subset of the functions in $D_{\langle s, \langle st, t \rangle \rangle}$ would qualify as conversational backgrounds), then the mapping between conversational backgrounds and accessibility relations might become one-to-one after all. In this light, consider the following potential restriction:

(85) Every conversational background f must be “closed under entailment”; i.e., it must meet this condition:
 $\forall w. \forall p [\cap f(w) \subseteq p \rightarrow p \in f(w)]$.

9 In this exercise, we systematically substitute sets for their characteristic functions. I.e., we pretend that $D_{\langle s, t \rangle}$ is the power set of W (i.e., elements of $D_{\langle s, t \rangle}$ are sets of worlds), and $D_{\langle st, t \rangle}$ is the power set of $D_{\langle s, t \rangle}$ (i.e., elements of $D_{\langle st, t \rangle}$ are sets of sets of worlds). On these assumptions, the definition in (84) can take the following form:

- (i) For any conversational background f of type $\langle s, \langle st, t \rangle \rangle$, we define the corresponding accessibility relation R_f of type $\langle s, st \rangle$ as follows:
 $R_f := \lambda w. \{w' : \forall p [p \in f(w) \rightarrow w' \in p]\}$.

The last line of this can be further abbreviated to:

- (ii) $R_f := \lambda w. \cap f(w)$

This formulation exploits a set-theoretic notation which we have also used in condition (85) of the second part of the exercise. It is defined as follows:

- (iii) If S is a set of sets, then $\cap S := \{x : \forall Y [Y \in S \rightarrow x \in Y]\}$.

(In words: if the propositions in $f(w)$ taken together entail p , then p must itself be in $f(w)$.) Show that this restriction would ensure that the mapping defined in (84) will be one-to-one. \square

Supplementary Readings

The most important background readings for this chapter are the following two papers by Kratzer:

KRATZER, Angelika: 1981. "The Notional Category of Modality." In H. J. Eikmeyer & H. Rieser (Editors) *Words, Worlds, and Contexts. New Approaches in Word Semantics*, pages 38–74. de Gruyter.

KRATZER, Angelika: 1991. "Modality." In Arnim von Stechow & Dieter Wunderlich (Editors) *Semantik: Ein internationales Handbuch der zeitgenössischen Forschung*, pages 639–650. Walter de Gruyter Berlin.

On the syntax of modals, there are only a few papers of uneven quality. Some of the more recent work is listed here. Follow up on older references from the bibliographies in these papers.

BHATT, Rajesh: 1997. "Obligation and Possession." In Heidi Harley (Editor) *Papers from the UPenn/MIT Roundtable on Argument Structure and Aspect*, volume 32 of *MIT Working Papers in Linguistics*. MIT Working Papers in Linguistics.

WURMBRAND, Susi: 1999. "Modal Verbs Must Be Raising Verbs." *West Coast Conference on Formal Linguistics (WCCFL)*, 18: 599–612. Preprint <http://www.arts.mcgill.ca/programs/linguistics/faculty/wurmbrand/research/files/WCCFL.pdf>.

CORMACK, Annabel & SMITH, Neil: 2002. "Modals and negation in English." In Sjef Barbiers, Frits Beukema, & Wim van der Wurff (Editors) *Modality and its Interaction with the Verbal System*, pages 133–163. Benjamins.

BUTLER, Jonny: 2003. "A Minimalist Treatment of Modality." *Lingua*, 113(10): 967–996. doi:10.1016/S0024-3841(02)00146-8. Preprint <http://www-users.york.ac.uk/~jrcbroo/minimalist-modality.pdf>.

The following paper explore some issues in the LF-syntax of epistemic modals:

VON FINTEL, Kai & IATRIDOU, Sabine: 2003. "Epistemic Containmentment." *Linguistic Inquiry*, 34(2): 173–198. doi:10.1162/002438903321663370. Offprint: <http://web.mit.edu/fintel/www/ec.pdf>.

The semantics of epistemic modals has become a hot topic recently. Here are the main references:

- DEROSE, Keith: 1991. "Epistemic Possibilities." *The Philosophical Review*, 100(4): 581–605.
- MACFARLANE, John: 2003. "Epistemic Modalities and Relative Truth." URL <http://socrates.berkeley.edu/~jmacf/epistmod.pdf>.
- EGAN, Andy, HAWTHORNE, John, & WEATHERSON, Brian: 2003. "Epistemic Modals in Context." URL <http://brian.weatherson.net/em.pdf>.
- EGAN, Andy: 2004. "Epistemic Modals, Relativism and Assertion." URL <http://www.geocities.com/eganamit/might.doc>. Ms.
- VON FINTEL, Kai & GILLIES, Anthony S.: 2005. "*Might* Made Right." URL <http://mit.edu/fintel/www/might.pdf>. Ms.
- The website for the Spring 2004 MIT seminar on modality (von Fintel & Iatridou) has more references and class handouts.

— THIS PAGE INTENTIONALLY LEFT BLANK —

We integrate conditionals into the semantics of modal expressions that we are developing. We show that the material implication analysis and the strict implication analysis are inferior to the restrictor analysis.

Contents

| | | |
|-----|-----------------------------------|----|
| 4.1 | The Material Implication Analysis | 43 |
| 4.2 | The Strict Implication Analysis | 46 |
| 4.3 | If-Clauses as Restrictors | 48 |
| | Supplemental Readings | 50 |

In this chapter, we will discuss some ways in which conditional sentences can be integrated into the semantics of modal expressions that we are developing. Our discussion will remain focussed on some simple questions and we refer you to the rich literature on conditionals for further topics.

4.1 The Material Implication Analysis

Consider the following example:

(86) If I am healthy, I will come to class.

The simplest analysis of such conditional constructions is the so-called MATERIAL IMPLICATION analysis, which treats *if* as contributing a truth-function operating on the truth-values of the two component sentences (which are called the ANTECEDENT and CONSEQUENT – from Latin – or PROTASIS and APODOSIS – from Greek). The lexical entry for *if* would look as follows:

(87) $\llbracket \text{if} \rrbracket = \lambda u \in D_t. \lambda v \in D_t. u = 0 \text{ or } v = 1.$

Applied to example in (86), this semantics would predict that the example is false just in case the antecedent is true, I am healthy, but the consequent false, I

do not come to class. Otherwise, the sentence is true. We will see that there is much to complain about here. But one should realize that under the assumption that *if* denotes a truth-function, *this one* is the most plausible candidate.

Suber [75] does a good job of persuading (or at least trying to persuade) recalcitrant logic students:

After saying all this, it is important to note that material implication does conform to some of our ordinary intuitions about implication. For example, take the conditional statement, *If I am healthy, I will come to class*. We can symbolize it: $H \supset C$.¹

The question is: when is this statement false? When will I have broken my promise? There are only four possibilities:

| H | C | $H \supset C$ |
|---|---|---------------|
| T | T | ? |
| T | F | ? |
| F | T | ? |
| F | F | ? |

- In case #1, I am healthy and I come to class. I have clearly kept my promise; the conditional is true.
- In case #2, I am healthy, but I have decided to stay home and read magazines. I have broken my promise; the conditional is false.
- In case #3, I am not healthy, but I have come to class anyway. I am sneezing all over you, and you're not happy about it, but I did not violate my promise; the conditional is true.
- In case #4, I am not healthy, and I did not come to class. I did not violate my promise; the conditional is true.

But this is exactly the outcome required by the material implication. The compound is only false when the antecedent is true and the consequence is false (case #2); it is true every other time.

Despite the initial plausibility of the analysis, it cannot be maintained. Consider this example:

- (88) If there is a major earthquake in Cambridge tomorrow, my house will collapse.

¹ The symbol \supset which Suber uses here is called the “horseshoe”. We have been using the right arrow \rightarrow as the symbol for implication. We think that this is much preferable to the confusing horseshoe symbol. There is an intimate connection between universal quantification, material implication, and the subset relation, usually symbolized as \subset , which is the other way round from the horseshoe. The horseshoe can be traced back to the notation introduced by Peano, a capital C standing for ‘consequenza’ facing backwards (Peano 1889). The C facing in the other direction was actually introduced first, but didn’t catch on (Gergonne 1817).

If we adopt the material implication analysis, we predict that (88) will be false just in case there is indeed a major earthquake in Cambridge tomorrow but my house fails to collapse. This makes a direct prediction about when the negation of (88) should be true. A false prediction, if ever there was one:

- (89) a. It's not true that if there is a major earthquake in Cambridge tomorrow, my house will collapse.
 b. \neq There will be a major earthquake in Cambridge tomorrow, and my house will fail to collapse.

Clearly, one might think that (89a) is true without at all being committed to what the material implication analysis predicts to be the equivalent statement in (89b). This is one of the inadequacies of the material implication analysis.

These inadequacies are sometimes referred to as the “paradoxes of material implication”. But that is misleading. As far as logic is concerned, there is nothing wrong with the truth-function of material implication. It is well-behaved and quite useful in logical systems. What is arguable is that it is not to be used as a reconstruction of what conditionals mean in natural language.

A problem that is not often raised for the material implication analysis is how badly it interacts with the analysis of modal expressions, once we look at sentences involving both a conditional clause and a modal. Consider:

- (90) If we are on Route 183, we might be in Lockhart now.
 (91) If you keep this fern dry, it cannot grow.

We need to consider two possible LFs for these sentences, depending on whether wider scope is given to the modal or to the conditional clause. For example, in the margin you see LFs A and B for (90).

The reading for (90) we have in mind is an epistemic one; imagine for instance that (90) is uttered in a car by Mary to Susan, while Susan is driving and Mary is looking at a map. The information provided by the map, together with other background knowledge, constitutes the relevant context for the modal *might* here. The accessibility relation is roughly this:

- (92) $\lambda w. \lambda w'. w'$ is compatible with what the map says in w and what Mary knows about the geography of the relevant area in w .

Let's suppose (90) is uttered in the actual world w_0 and we are interested in its truth-value at this world. We now proceed to show that neither of the LFs A and B represent the intuitively natural meaning of (90) if we assume the material implication analysis of *if*.

Consider first LF A. There are two respects in which the predicted truth-conditions for this LF deviate from intuitive judgment. First, suppose that Susan and Mary are not on Route 183 in w_0 . Then (90) is predicted to be true

in w_0 , regardless of the geographical facts, e.g. even if Lockhart is nowhere near Route 183. This is counterintuitive. Imagine the following quite sensible dialogue:

- (93) Mary: If we are on Route 183, we might be in Lockhart now.
 Susan (stops the car and looks at the map): You are wrong. Look here, Route 183 doesn't run anywhere near Lockhart.

If Mary concedes Susan's claim that Route 183 doesn't go through Lockhart, she has to also concede that her original assertion was false. It wouldn't do for her to respond: "I know that 183 runs about 10 miles east of Lockhart, but maybe we are not on Route 183, so I may still be right." Yet we predict that this should be a reasonable way for her to defend (90).

A second inadequacy is this: we predict that the truth of the consequent of (90) is a sufficient condition for the truth of (90) as a whole. If this were right, it would take very little for (90) to be true. As long as the map and the rest of Mary's knowledge in w_0 don't rule out the possibility that they are in Lockhart, *we might be in Lockhart* will be true in w_0 – regardless, once again, of whether Lockhart is anywhere near 183. It should therefore be reasonable for Mary to continue the dialogue in (93) with the rejoinder: "But how can you be so sure we are not in Lockhart?" According to intuitive judgment, however, this would not be a pertinent remark and certainly would not help Mary defend (90) against Susan's objection.

Now let's look at LF B, where the modal has widest scope. Given the material implication analysis of *if*, this is predicted to mean, in effect: "It might be the case that we are either in Lockhart or not on Route 183". This truth-condition is also far too easy to satisfy: All it takes is that the map and the rest of Mary's knowledge in w_0 are compatible with Mary and Susan not being on Route 183, or that they are compatible with their being in Lockhart. So as long as it isn't certain that they are on Route 183, Mary should be justified in asserting (90), regardless, once again, of her information about the relative location of Lockhart and Route 183.

EXERCISE 4.1: Show that similar difficulties arise for the analysis of (91). □

4.2 The Strict Implication Analysis

Some of the problems we encountered would go away if we treated *if* as introducing a modal meaning. The simplest way to do that would be to treat it as a universal quantifier over possible worlds. *If p, q* would simply mean that the set of p-worlds is a subset of the q-worlds. This kind of analysis is usually called STRICT IMPLICATION. The difference between *if* and *must* would be that

if takes an overt restrictive argument. Here what the lexical entry for *if* might look like:

$$(94) \quad \llbracket \text{if} \rrbracket^{w,g} = \lambda p \in D_{\langle s,t \rangle}. \lambda q \in D_{\langle s,t \rangle}. \forall w' : p(w') = 1 \rightarrow q(w') = 1.$$

(in set talk: $p \subseteq q$)

Applied to (88), we would derive the truth-conditions that (88) is true iff all of the worlds where there is a major earthquake in Cambridge tomorrow are worlds where my house collapses.

We immediately note that this analysis has the same problem of non-contingency that we faced with one of our early attempts at a quantificational semantics for modals like *must* and *may*. The obvious way to fix this here is to assume that *if* takes a covert accessibility function as one of its arguments. The antecedent clause then serves as an additional restrictive device. Here is the proposal:

$$(95) \quad \llbracket \text{if} \rrbracket^{w,g} = \lambda R \in D_{\langle s, \langle s,t \rangle \rangle}. \lambda p \in D_{\langle s,t \rangle}. \lambda q \in D_{\langle s,t \rangle}.$$

$$\forall w' : (R(w)(w') = 1 \ \& \ p(w') = 1) \rightarrow q(w') = 1.$$

(in set talk: $R(w) \cap p \subseteq q$)

If we understand (88) as involving an epistemic accessibility relation, it would claim that among the worlds epistemically accessible from the actual world (i.e. the worlds compatible with what we know), those where there is a major earthquake in Cambridge tomorrow are worlds where my house collapses. This would appear to be quite adequate – although potentially traumatic to me.

EXERCISE 4.2: Can you come up with examples where a conditional is interpreted relative to a non-epistemic accessibility relation? \square

EXERCISE 4.3: What prediction does the strict implication analysis make about the negated conditional in (89a)? \square

What happens when we let this analysis loose on (90)? We again need to assess two LFs depending on the relative scope of *if* and *might*. Both LFs would have two covert variables over accessibility relations, one for *if* and one for *might*. Before we can assess the adequacy of the two candidate analyses, we need to decide what the contextually salient values for the accessibility relations might be. One would think that the epistemic accessibility relation that we have already encountered is the most likely value, and in fact for both variables.

Next, we need to consider the particular epistemic state that Mary is in. By assumption, Mary does not know where they are. Nothing in her visual environment helps her figure out where they are. She does see from the map that if they are on Route 183, one of the towns they might be in is Lockhart. But she doesn't know whether they are on Route 183. Even if they *are* on 183,

she doesn't know that they are and her epistemic state would still be what it is: one of being lost.

Consider then LF A', with the modal in the scope of the conditional. Here, we derive the claim that all worlds w' compatible with what Mary knows in w and where they are on 183 are such that some world w'' compatible with what Mary knows in w' is such that they are in Lockhart. Is that adequate? Not really. We have just convinced ourselves that whether they are on 183 or not has no relevant influence on Mary's epistemic state, since she wouldn't know it either way. But that means that our analysis would predict that (90) is true as long as it is possible as far as Mary knows that they are in Lockhart. Whether they are on 183 or not doesn't change that. So, we would expect (90) to not be distinct in truth-value from something like:

(96) If we are on the turnpike, we might be in Lockhart.

But that is not right – Mary knows quite well that if they are on the turnpike, they cannot be in Lockhart.

Turning to LF B', with the modal having widest scope, doesn't help us either. Here, we would derive the claim that it is compatible with what Mary knows that from being on 183 it follows (according to what she knows) that they are in Lockhart. Clearly, that is not what (90) means. Mary doesn't consider it possible that if they are on 183, she knows that they are in Lockhart. After all, she's well aware that she doesn't know where they are.

4.3 *If*-Clauses as Restrictors

The problem we have encountered here with the interaction of an *if*-clause and the modal operator *might* is similar to others that have been noted in the literature. Most influentially, David Lewis in his paper "Adverbs of Quantification" showed how hard it is to find an adequate analysis of the interaction of *if*-clauses and ADVERBS OF QUANTIFICATION like *never*, *rarely*, *sometimes*, *often*, *usually*, *always*. Lewis proposed that in the cases he was considering, the adverb is the only operator at work and that the *if*-clause serves to restrict the adverb. Thus, it has much the same function that a common noun phrase has in a determiner-quantification.

The *if* of our restrictive *if*-clauses should not be regarded as a sentential connective. It has no meaning apart from the adverb it restricts. The *if* in *always if*..., ..., *sometimes if*..., ..., and the rest is on a par with the non-connective *and* in *between ... and*..., with the non-connective *or* in *whether ... or*..., or with the non-connective *if* in *the probability that ... if*.... It serves merely to mark an argument-place in a polyadic construction. [51: 11]

Building on all these insights, Kratzer argued for a uniform treatment of *if*-clauses as restrictors. She claimed that

the history of the conditional is the story of a syntactic mistake. There is no two-place *if*...*then* connective in the logical forms of natural languages. *If*-clauses are devices for restricting the domains of various operators. [46]

Let us repeat this:

(97) KRATZER'S THESIS

If-clauses are devices for restricting the domains of various operators.

Kratzer's Thesis gives a unified picture of the semantics of conditional clauses. Note that it is not meant to supplant previous accounts of the meaning of conditionals. It just says that what those accounts are analyzing is not the meaning of *if* itself but the meaning of the operators that *if*-clauses restrict.

Let us see how this idea helps us with our Lockhart-sentence. The idea is to deny that there are two quantifiers over worlds in (90). Instead, the *if*-clause merely contributes a further restriction to the modal *might*. In effect, the modal is not quantifying over *all* the worlds compatible with Mary's knowledge but only over those where they are on Route 183. It then claims that at least some of those worlds are worlds where they are in Lockhart. We cannot anymore derive the problematic conclusion that it should also be true that if they are on the turnpike, they might be in Lockhart. In all, we have a good analysis of what (90) means.

What we don't yet have is a compositional calculation. What does it mean in structural terms for the *if*-clause to be restricting the domain of the modal? We will assume a structure as in LF C. Here, the *if*-clause is the sister to what used to be the covert set-of-worlds argument of the modal. As you can see, we have chosen the variant of the semantics for modals that was discussed in Section 3.2.5. The idea now is that the two restrictive devices work together: we just feed to the modal the *intersection* of (i) the set of worlds that are R-accessible from the actual world, and (ii) the set of worlds where they are on Route 183.

EXERCISE 4.4: To make the composition work, we need to be able to intersect the set of accessible worlds with the antecedent proposition. This could be done in two ways: (i) a new composition principle, which would be a slight modification of the PREDICATE MODIFICATION rule, (ii) give *if* a functional meaning that accomplishes the intersection. Formulate such a meaning for *if*.

Alternatively, we could do without the w^* device and instead give *if* a meaning that takes a proposition p and then modifies an accessibility relation to give a new accessibility relation, which is restricted to p -worlds. Formulate such a meaning for *if*. □

What about cases like (88), now? Here there is no modal operator for the *if*-clause to restrict. Should we revert to treating *if* as an operator on its own? Kratzer proposes that we should not and that such cases simply involve covert modal operators. We will have nothing to say about that here.

Supplementary Readings

Overviews of the philosophical work on conditionals are:

EDGINGTON, Dorothy: 1995. "On Conditionals." *Mind*, 104: 235–329.

BENNETT, Jonathan: 2003. *A Philosophical Guide to Conditionals*. Oxford University Press.

A handbook article on the logic of conditionals:

NUTE, Donald: 1984. "Conditional Logic." In Dov Gabbay & Franz Guenther (Editors) *Handbook of Philosophical Logic. Volume II*, pages 387–439. Dordrecht: Reidel.

Three indispensable classics:

LEWIS, David: 1973. *Counterfactuals*. Oxford: Blackwell.

STALNAKER, Robert: 1968. "A Theory of Conditionals." In Nicholas Rescher (Editor) *Studies in Logical Theory*, pages 98–112. Oxford: Blackwell.

STALNAKER, Robert: 1975. "Indicative Conditionals." *Philosophia*, 5: 269–286.

A pragmatic defense of material implication (but see Bennett's arguments against):

JACKSON, Frank: 1987. *Conditionals*. Oxford: Blackwell.

The Restrictor Analysis:

LEWIS, David: 1975. "Adverbs of Quantification." In Edward Keenan (Editor) *Formal Semantics of Natural Language*, pages 3–15. Cambridge University Press.

KRATZER, Angelika: 1986. "Conditionals." *Chicago Linguistics Society*, 22(2): 1–15. Reprinted in [74], pages 651–656.

VON FINTEL, Kai & IATRIDOU, Sabine: 2002. "If and When *If*-Clauses Can Restrict Quantifiers." URL <http://web.mit.edu/fintel/www/lpw.mich.pdf>. Unpublished ms, MIT, contribution to the Workshop in Linguistics & Philosophy at the University of Michigan, November 8–10, 2002.

Syntax of conditionals:

BHATT, Rajesh & PANCHEVA, Roumyana: 2001. "Conditionals." URL <http://www-rcf.usc.edu/~pancheva/cond.pdf>.

Tense/Aspect in conditionals:

IATRIDOU, Sabine: 2000. “The Grammatical Ingredients of Counterfactuality.” *Linguistic Inquiry*, 31(2): 231–270. doi:10.1162/002438900554352.

IPPOLITO, Michela: 2003. “Presuppositions and Implicatures in Counterfactuals.” *Natural Language Semantics*, 11(2): 145–186. doi:10.1023/A:1024411924818.

More references at the end of the next chapter.

— THIS PAGE INTENTIONALLY LEFT BLANK —

We see that the semantics for modals (and conditionals) needs to make reference to an ordering among accessible worlds.

Contents

| | | |
|-----|--|----|
| 5.1 | The Driveway | 53 |
| 5.2 | Kratzer's Solution: Doubly Relative Modality | 54 |
| 5.3 | The Paradox of the Good Samaritan | 56 |
| 5.4 | Kratzer's Version of the Samaritan Paradox | 57 |
| 5.5 | Non-Monotonicity of Conditionals | 57 |
| | Supplemental Readings | 59 |

We have stressed throughout the previous two chapters that there are numerous parallels between quantification over ordinary individuals via determiner quantifiers and quantification over possible worlds via modal operators (including conditionals). Now, we turn to a phenomenon that (at least at first glance) appears to show that there are non-parallels as well: a sensitivity to an ORDERING of the elements in the domain of quantification. We first look at this in the context of simple modal sentences and later we'll look at conditionals.

5.1 The Driveway

Consider a typical use of a sentence like (98).

(98) John must pay a fine.

This is naturally understood in such a way that its truth depends both on facts about the law and facts about what John has done. For instance, it will be judged true if (i) the law states that driveway obstructors are fined, and (ii) John has obstructed a driveway. It may be false either because the law is different or because John's behavior was different.

What accessibility relation provides the implicit restriction of the quantifier *must* on this reading of (98)? A naïve attempt might go like this:

- (99) $\lambda w. \lambda w'. [\text{what happened in } w' \text{ up to now is the same as what happened in } w, \text{ and } w' \text{ conforms to what the law in } w \text{ demands}]$.

The problem with (99) is that, unless there were no infractions of the law at all in w up to now, no world w' will be accessible from w . Therefore, (98) is predicted to follow logically from the premise that John broke some law. This does not represent our intuition about its truth conditions.

A better definition of the appropriate accessibility relation has to be more complicated:

- (100) $\lambda w. \lambda w'. [\text{what happened in } w' \text{ up to now is the same as what happened in } w, \text{ and } w' \text{ conforms at least as well to what the law in } w \text{ demands as does any other world in which what happened up to now is the same as in } w]$.

(100) makes explicit that there is an important difference between the ways in which facts about John's behavior on the one hand, and facts about the law on the other, enter into the truth conditions of sentences like (98). Worlds in which John didn't do what he did are simply excluded from the domain of *must* here. Worlds in which the law isn't obeyed are not absolutely excluded. Rather, we restrict the domain to those worlds in which the law is obeyed as well as it can be, considering what has happened. We exclude only those worlds in which there are infractions above and beyond those that are shared by all the worlds in which John has done what he has done. The analysis of (98) thus crucially involves the notion of an ordering of worlds: here they are ordered according to how well they conform to what the law in w demands.

5.2 Kratzer's Solution: Doubly Relative Modality

Kratzer proposes that modal operators are sensitive to *two* context-dependent parameters: a set of accessible worlds (provided by an accessibility function computed from a conversational background, the MODAL BASE), and a partial ordering of the accessible worlds (computed from another conversational background, called the ORDERING SOURCE).

Let's see how the analysis applies to the previous example.

- The modal base will be a function that assigns to any evaluation world a set of propositions describing the relevant circumstances, for example, what John did. Since in our stipulated evaluation world John obstructed a driveway, the modal base will assign the proposition that John obstructed

a driveway to this world. The set of worlds accessible from the evaluation world will thus only contain worlds where John obstructed a driveway.

- The ordering source will be a function that assigns to any evaluation world a set of propositions \mathcal{P} whose truth is demanded by the law. Imagine that for our evaluation world this set of propositions contains (among others) the following two propositions: (i) nobody obstructs any driveways, (ii) anybody who obstructs a driveway pays a fine.
- The idea is now that such a set \mathcal{P} of propositions can be used to order the worlds in the modal base. For any pair of worlds w_1 and w_2 , we say that w_1 comes closer than w_2 to the ideal set up by \mathcal{P} (in symbols: $w_1 <_{\mathcal{P}} w_2$), iff the set of propositions from \mathcal{P} that are true in w_2 is a proper subset of the set of propositions from \mathcal{P} that are true in w_1 .
- For our simple example then, any world in modal base where John pays a fine will count as better than an otherwise similar world where he doesn't.
- Modals then make quantificational claims about the best worlds in the modal base (those for which there isn't a world that is better than them).
- In our case, (98) claims that in the best worlds (among those where John obstructed a driveway), he pays a fine.

More technically:

(IO1) Given a set of worlds X and a set of propositions \mathcal{P} , define the STRICT PARTIAL ORDER $<_{\mathcal{P}}$ as follows:

$$\forall w_1, w_2 \in X : w_1 <_{\mathcal{P}} w_2 \text{ iff } \{p \in \mathcal{P} : p(w_2) = 1\} \subset \{p \in \mathcal{P} : p(w_1) = 1\}.$$

(IO2) For a given strict partial order $<_{\mathcal{P}}$ on worlds, define the selection function $\max_{\mathcal{P}}$ that selects the set of $<_{\mathcal{P}}$ -best worlds from any set X of worlds:

$$\forall X \subseteq W : \max_{\mathcal{P}}(X) = \{w \in X : \neg \exists w' \in X : w' <_{\mathcal{P}} w\}.$$

(IO3) $\llbracket \text{must} \rrbracket^{w,g} = \lambda f_{\langle s, st \rangle} . \lambda g_{\langle s, st \rangle} . \lambda q_{\langle s, t \rangle} .$

$$\forall w' \in \max_{g(w)}(\cap f(w)) : q(w') = 1.$$

TECHNICAL NOTE: This^t only works if we can in general assume that the $<_{\mathcal{P}}$ relation has minimal elements, that there always are accessible worlds that come closest to the \mathcal{P} -ideal, worlds that are better than any world they can be compared with via $<_{\mathcal{P}}$. It is possible, with some imagination, to cook up scenarios where this assumption fails. This problem has been discussed primarily in the area of the semantics of conditionals. There, Lewis presents relevant scenarios and argues that one shouldn't make this assumption, which he calls the Limit Assumption. Stalnaker, on the one other hand, defends the assumption against Lewis' arguments by saying that in actual practice, in actual natural language

¹ For discussion see: Lewis [50], Stalnaker [71: Chapter 7, esp. pp. 140-142]. Further arguments against the Limit Assumption: Herzberger [32], Pollock [64]. Further arguments for the Limit Assumption: Warmbrod [77].

semantics and in actual modal/conditional reasoning, the assumption is eminently reasonable. Kratzer is persuaded by Lewis' evidence and does not make the Limit Assumption; hence her semantics for modals is more convoluted than what we have in (102) and (103). I will side with Stalnaker, not the least because it makes life easier.

EXERCISE 5.1: In her handbook article [47], Kratzer presents a number of examples of modal statements and sketches an analyses in terms of doubly relative modality. You should study her examples carefully. □

5.3 The Paradox of the Good Samaritan

Prior [67] introduced the following “Paradox of the Good Samaritan”. Imagine that someone has been robbed and John is walking by. It is easy to conceive of a code of ethics that would make the following sentence true:

(104) John ought to help the person who was robbed.

In our previous one-factor semantics for modals, we would have said that (104) says that in all of the deontically accessible worlds (those compatible with the code of ethics) John helps the person who was robbed. Prior's point was that under such a semantics, something rather unfortunate holds. Notice that in all of the worlds where John helps the person who was robbed, someone was robbed in the first place. Therefore, it will be true that in all of the deontically accessible worlds, someone was robbed. Thus, (104) will entail:

(105) It ought to be the case that someone was robbed.

It clearly would be good not make such a prediction.

The doubly-relative analysis of modality can successfully avoid this unfortunate prediction. We conceive of (104) as being uttered with respect to a circumstantial modal base that includes the fact that someone was robbed. Among those already somewhat ethically deficient worlds, the relatively best ones are all worlds where John helps the victim.

Now, at first, it seems we still have that among the worlds in the modal base, all are worlds where someone was robbed, and we would thus appear to still make the prediction that (105) should be true. But this can now be fixed. For example, we could say that *ought* p is semantically defective if p is true throughout the worlds in the modal base. This could be a presupposition or some other ingredient of meaning. So, with respect to a modal base which pre-determines that someone was robbed, one couldn't felicitously say (105).

Consequently, saying (105) would only be felicitous if a different modal base is intended, one that contains both p and non-p worlds. And given a choice between worlds where someone was robbed and worlds where nobody was robbed,

most deontic ordering sources would probably choose the no-robbery worlds, which would make (105) false, as desired.

5.4 Kratzer's Version of the Samaritan Paradox

[to be written – see Kratzer's Handbook article]

5.5 Non-Monotonicity of Conditionals

The crucial role of an ordering of worlds in modal semantics also surfaces in the semantics of conditionals, as we would of course expect under the analysis of *if*-clauses as restrictors of modal operators. In this arena, the discussion usually revolves around the failure of certain inference patterns, which one would expect a universal quantifier to validate. Here are the most important ones:

- (106) LEFT DOWNWARD MONOTONICITY ("DOWNWARD ENTAILINGNESS")
Every A is a B. \rightarrow Every A & C is a B.
- (107) TRANSITIVITY
Every A is a B. Every B is a C. \rightarrow Every A is a C.
- (108) CONTRAPOSITION
Every A is a B. \rightarrow Every non-B is a non-A.

Conditionals were once thought to obey these patterns as well, known in conditional logic as STRENGTHENING THE ANTECEDENT, HYPOTHETICAL SYLLOGISM, and CONTRAPOSITION. But then spectacular counterexamples became known through the work of Stalnaker and Lewis.

- (109) FAILURE OF STRENGTHENING THE ANTECEDENT
 - a. If I strike this match, it will light.
If I dip this match into water and strike it, it will light.
 - b. If John stole the earrings, he must go to jail.
If John stole the earrings and then shot himself, he must go to jail.
 - c. If kangaroos had no tails, they would topple over. If kangaroos had no tails but used crutches, they would topple over.
- (110) FAILURE OF THE HYPOTHETICAL SYLLOGISM (TRANSITIVITY)
 - a. If Brown wins the election, Smith will retire to private life.
If Smith dies before the election, Brown will win the election.
If Smith dies before the election, Smith will retire to private life.
 - b. If Hoover had been a Communist, he would have been a traitor.
If Hoover had been born in Russia, he would have been a Com-

munist.

If Hoover had been born in Russia, he would have been a traitor.

(III) FAILURE OF CONTRAPOSITION

a. If it rained, it didn't rain hard.

If it rained hard, it didn't rain.

b. (Even) if Goethe hadn't died in 1832, he would still be dead now.

If Goethe were alive now, he would have died in 1832.

Note that there are examples of both "indicative" (epistemic) conditionals and counterfactual conditionals. It is sometimes thought that indicative conditionals are immune from these kinds of counterexamples, but it is clear that they are not. Also note that in (109b) we have a case of Failure of Strengthening the Antecedent with a deontic conditional. Deontic counterexamples to the other patterns seem harder to find.

The failure of these inference patterns indicates that the semantics of modal operators (restricted by *if*-clauses) is more complicated than the simple universal quantification we have been assuming. The intuitive diagnosis in all the trouble cases is that during the course of the inference, the modal quantifiers are suddenly quantifying over worlds that were not in the domain of quantification in the earlier steps.

The basic idea of most approaches to this problem is this: the semantics of conditionals is more complicated than simple universal quantification. The conditional does not make a claim about simply every antecedent world, nor even about every contextually relevant antecedent world. Instead, in each of the conditional statements, only a particular subset of the antecedent worlds is quantified over. Informally, we can call those the "most highly ranked antecedent worlds". Consider:

(II2) If I had struck this match, it would have lit.

If I had dipped this match into water and struck it, it would have lit.

According to the Stalnaker-Lewis account, this inference is semantically invalid. The premise merely claims that the most highly ranked worlds in which I strike this match are such that it lights. No claim is made about the most highly ranked worlds in which I first dip this match into water and then strike it. Strengthening the Antecedent will only be safe if it is additionally known that the strengthened antecedent is instantiated among the worlds that verify the original antecedent.

The other fallacies receive similar treatments. Transitivity (Hypothetical Syllogism) fails for the new non-monotonic quantifier because even if all the most highly rated *p*-worlds are *q*-worlds and all the most highly rated *q*-worlds are *r*-worlds, we are not necessarily speaking about the same *q*-worlds (the *q*-worlds that *p* takes us to may be rather remote ones). So in the Hoover-example,

we get the following picture: The most highly ranked p-worlds in which Hoover was born in Russia (but where he retains his level of civic involvement), are all q-worlds in which he becomes a Communist. On the other hand, the most highly ranked q-worlds in which he is a Communist (but retaining his having been born in the United States and being a high level administrator) are all r-worlds in which he is a traitor. However, the most highly ranked p-worlds do not get us to the most highly ranked q-worlds, so the Transitive inference does not go through.

Contraposition fails because the fact that the most highly rated p-worlds are q-worlds does not preclude a situation where the most highly rated non q-worlds are also p-worlds. The most highly rated p-worlds in which Goethe didn't die in 1832 are all q-worlds where he dies nevertheless (well) before the present. But of course, the most highly rated (in fact, all) non-q-worlds (where he is alive today) are also p-worlds where he didn't die in 1832.

[much more to be written]

Supplementary Readings

The central readings for this chapter are two papers by Kratzer:

KRATZER, Angelika: 1991. "Modality." In Arnim von Stechow & Dieter Wunderlich (Editors) *Semantik: Ein internationales Handbuch der zeitgenössischen Forschung*, pages 639–650. Walter de Gruyter Berlin.

KRATZER, Angelika: 1981. "The Notional Category of Modality." In H. J. Eikmeyer & H. Rieser (Editors) *Words, Worlds, and Contexts. New Approaches in Word Semantics*, pages 38–74. de Gruyter.

Some work that discusses and uses Kratzer's two factor semantics for modals:

FRANK, Anette: 1996. *Context Dependence in Modal Constructions*. Ph.D. thesis, Universität Stuttgart. URL <http://www.dfki.de/~frank/papers/header.ps.gz>.

VON FINTEL, Kai & IATRIDOU, Sabine: 2004. "What to Do If You Want to Go to Harlem: Notes on Anankastic Conditionals and Related Matters." <http://web.mit.edu/fintel/www/harlem.pdf>.

Some work of mine that discusses whether non-monotonicity might have to be relegated to a dynamic pragmatic component of meaning:

VON FINTEL, Kai: 2001. "Counterfactuals in a Dynamic Context." In Michael Kenstowicz (Editor) *Ken Hale: A Life in Language*, pages 123–152. MIT Press Cambridge, MA. Preprint version: <http://web.mit.edu/fintel/www/conditional.pdf>.

VON FINTEL, Kai: 1999. “NPI Licensing, Strawson Entailment, and Context Dependency.” *Journal of Semantics*, 16(2): 97–148. URL http://www3.oup.co.uk/semant/hdb/Volume_16/Issue_02/160097.sgm.abs.html. Preprint: <http://web.mit.edu/fintel/www/npi.pdf>.

[More references to come.]

DPS AND SCOPE IN MODAL C

We discuss ambiguities that arise when DPs occur in modal contexts.

Contents

| | | |
|-------|--|----|
| 6.1 | <i>De re</i> vs. <i>De dicto</i> as a Scope Ambiguity | 61 |
| 6.2 | Raised subjects | 65 |
| 6.2.1 | Examples of <i>de dicto</i> readings for raised subjects | 65 |
| 6.2.2 | Syntactic “Reconstruction” | 69 |
| 6.2.3 | Some Alternatives to Syntactic Reconstruction | 71 |

6.1 *De re* vs. *De dicto* as a Scope Ambiguity

When a DP appears inside the clausal or VP complement of a modal predicate¹, there is often a so-called *de re-de dicto* ambiguity. A classic example is (113), which contains the DP *a plumber* inside the infinitive complement of *want*.

(113) John wants to marry a plumber.

According to the *de dicto* reading, every possible world in which John gets what he wants is a world in which there is a plumber whom he marries. According to the *de re* reading, there is a plumber in the actual world whom John marries in every world in which he gets what he wants. We can imagine situations in which one of the readings is true and the other one false.

¹ We will be using the terms “modal operator” and “modal predicate” in their widest sense here, to include modal auxiliaries (“modals”), modal main verbs and adjectives, attitude predicates, and also modalizing sentence-adverbs like *possibly*.

For example, suppose John thinks that plumbers make ideal spouses, because they can fix things around the house. He has never met one so far, but he definitely wants to marry one. In this scenario, the *de dicto* reading is true, but the *de re* reading is false. What all of John's desire-worlds have in common is that they have a plumber getting married to John in them. But it's not the same plumber in all those worlds. In fact, there is no particular individual (actual plumber or other) whom he marries in every one of those worlds.

For a different scenario, suppose that John has fallen in love with Robin and wants to marry Robin. Robin happens to be a plumber, but John doesn't know this; in fact, he wouldn't like it and might even call off the engagement if he found out. Here the *de re* reading is true, because there is an actual plumber, viz. Robin, who gets married to John in every world in which he gets what he wants. The *de dicto* reading is false, however, because the worlds which conform to John's wishes actually do not have him marrying a plumber in them. In his favorite worlds, he marries Robin, who is not a plumber in those worlds.

When confronted with this second scenario, you might, with equal justification, say 'John wants to marry a plumber', or 'John *doesn't* want to marry a plumber'. Each can be taken in a way that makes it a true description of the facts – although, of course, you cannot assert both in the same breath. This intuition fits well with the idea that we are dealing with a genuine ambiguity.²

Let's look at another example:

(114) John believes that your abstract will be accepted.

² What is behind the Latin terminology "de re" (lit.: 'of the thing') and "de dicto" (lit.: 'of what is said')? Apparently, the term "de dicto" is to indicate that on this reading, the *words* which I, the speaker, am using to describe the attitude's content, are the same (at least as far as the relevant DP is concerned) as the words that the subject herself would use to express her attitude. Indeed, if we asked the John in our example what he wants, then in the first scenario he'd say "marry *a plumber*", but in the second scenario he would not use these words. The term "de re", by contrast, indicates that there is a common *object* (here: Robin) whom I (the speaker) am talking about when I say "a plumber" in my report and whom the attitude holder would be referring to if he were to express his attitude in his own words. E.g., in our second scenario, John might say that he wanted to marry "Robin", or "this person here" (pointing at Robin). He'd thus be referring to the same *person* that I am calling "a plumber", but wouldn't use that same description.

Don't take this "definition" of the terms too seriously, though! The terminology is much older than any precise truth-conditional analysis of the two readings, and it does not, in hindsight, make complete sense. We will also see below that there are cases where nobody is sure how to apply the terms in the first place, even as purely descriptive labels. So in case of doubt, it is always wiser to give a longer, more detailed, and less terminology-dependent description of the relevant truth-conditional judgments.

Here the relevant DP in the complement clause of the verb *believe* is *your abstract*. Again, we detect an ambiguity, which is brought to light by constructing different scenarios.

- (i) John's belief may be about an abstract that he reviewed, but since the abstract is anonymous, he doesn't know who wrote it. He told me that there was a wonderful abstract about subjacency in Hindi that is sure to be accepted. I know that it was your abstract and inform you of John's opinion by saying (114). This is the *de re* reading. In the same situation, the *de dicto* reading is false: Among John's belief worlds, there are many worlds in which *your abstract will be accepted* is not true or even false. For all he knows, you might have written, for instance, that terrible abstract about Antecedent-Contained Deletion, which he also reviewed and is positive will be rejected.
- (ii) For the other scenario, imagine that you are a famous linguist, and John doesn't have a very high opinion about the fairness of the abstract selection process. He thinks that famous people never get rejected, however the anonymous reviewers judge their submissions. He believes (correctly or incorrectly – this doesn't matter here) that you submitted a (unique) abstract. He has no specific information or opinion about the abstract's content and quality, but given his general beliefs and his knowledge that you are famous, he nevertheless believes that your abstract will be accepted. This is the *de dicto* reading. Here it is true in all of John's belief worlds that you submitted a (unique) abstract and it will be accepted. The *de re* reading of (114), though, may well be false in this scenario. Suppose – to flesh it out further – the abstract you actually submitted is that terrible one about ACD. That one surely doesn't get accepted in every one of John's belief worlds. There may be some where it gets in (unless John is certain it can't be by anyone famous, he has to allow at least the possibility that it will get in despite its low quality). But there are definitely also belief-worlds of his in which it doesn't get accepted.

We have taken care here to construct scenarios that make one of the readings true and the other false. This establishes the existence of two distinct readings. We should note, however, that there are also many possible and natural scenarios that simultaneously support the truth of *both* readings. Consider, for instance, the following third scenario for sentence (114).

- (iii) John is your adviser and is fully convinced that your abstract will be accepted, since he knows it and in fact helped you when you were writing it. This is the sort of situation in which both the *de dicto* and the *de re* reading are true. It is true, on the one hand, that the sentence *your abstract will be accepted* is true in every one of John's belief worlds (*de dicto* reading). And on the other hand, if we ask whether the abstract which you actually wrote will get accepted in each of John's belief worlds, that is likewise true (*de re*

reading).

In fact, this kind of “doubly verifying” scenario is very common when we look at actual uses of attitude sentences in ordinary conversation. There may even be many cases where communication proceeds smoothly without either the speaker or the hearer making up their minds as to which of the two readings they intend or understand. It doesn’t matter, since the possible circumstances in which their truth-values would differ are unlikely and ignorable anyway. Still, we *can* conjure up scenarios in which the two readings come apart, and our intuitions about those scenarios do support the existence of a semantic ambiguity.

In the paraphrases by which we have elucidated the two readings of our examples, we have already given away the essential idea of the analysis that we will adopt: We will treat *de dicto-de re* ambiguities as ambiguities of *scope*. The *de dicto* readings, it turns out, are the ones which we predict without further ado if we assume that the position of the DP at LF is within the modal predicate’s complement. (That is, it is either *in situ* or QRed within the complement clause.) For example:

(115) John wants [[a plumber]_i [PRO₂ to marry t_i]]

(116) John believes [the abstract-by-you will-be-accepted]

To obtain the *de re* readings, we apparently have to QR the DP to a position above the modal predicate, minimally the VP headed by *want* or *believe*.

(117) [a plumber]_i [John wants [PRO₂ to marry t_i]]

(118) [the abstract-by-you]_i [John believes will-be-accepted]]

EXERCISE 6.1: Calculate the interpretations of the four structures in (115)–(118), and determine their predicted truth-values in each of the (types of) possible worlds that we described above in our introduction to the ambiguity.

Some assumptions to make the job easier: (i) Assume that (115) and (117) are evaluated with respect to a variable assignment that assigns John to the number 2. This assumption takes the place of a worked out theory of how controlled PRO is interpreted. (ii) Assume that *abstract-by-you* is an unanalyzed one-place predicate. This takes the place of a worked out theory of how genitives with a non-possessive meaning are to be analyzed. □

6.2 Raised subjects

In the examples of *de re-de dicto* ambiguities that we have looked at so far, the surface position of the DP in question was inside the modal predicate's clausal or VP-complement. We saw that if it stays there at LF, a *de dicto* reading results, and if it covertly moves up above the modal operator, we get a *de re* reading. In the present section, we will look at cases in which a DP that is superficially *higher* than a modal operator can still be read *de dicto*. In these cases, it is the *de re* reading which we obtain if the LF looks essentially like the surface structure, and the *de dicto* reading for which we apparently have to posit a non-trivial covert derivation.

6.2.1 Examples of *de dicto* readings for raised subjects

Suppose I come to my office one morning and find the papers and books on my desk in different locations than I remember leaving them the night before. I say:

(119) Somebody must have been here (since last night).

On the assumptions we have been making, *somebody* is base-generated as the subject of the VP *be here* and then moved to its surface position above the modal. So (119) has the following S-structure, which is also an interpretable LF.

(120) somebody [λ_2 [[must R] [t_2 have-been-here]]]

What does (120) mean? The appropriate reading for *must* here is epistemic, so suppose the variable R is mapped to the relation [$\lambda w.\lambda w'. w'$ is compatible with what I believe in w]. Let w_o be the utterance world. Then the truth-condition calculated by our rules is as follows.

(121) $\exists x[x \text{ is a person in } w_o \ \& \ \forall w'[w' \text{ is compatible with what I believe in } w_o \rightarrow x \text{ was here in } w']]$

But this is not the intended meaning. For (121) to be true, there has to be a person who in every world compatible with what I believe was in my office. In other words, all my belief-worlds have to have one and the same person coming to my office. But this is not what you intuitively understood me to be saying about my belief-state when I said (119). The context we described suggests that I do not know (or have any opinion about) which person it was that was in my office. For all I know, it might have been John, or it might have been Mary, or it

have been this stranger here, or that stranger there. In each of my belief-worlds, somebody or other was in my office, but no one person was there in all of them. I do not believe of anyone in particular that he or she was there, and you did not understand me to be saying so when I uttered (119). What you did understand me to be claiming, apparently, was not (121) but (122).

- (122) $\forall w'[w' \text{ is compatible with what I believe in } w_o$
 $\rightarrow \exists x [x \text{ is a person in } w' \ \& \ x \text{ was here in } w']]$

In other words – to use the terminology we introduced in the last section – the DP *somebody* in (119) appears to have a *de dicto* reading.

How can sentence (119) have the meaning in (122)? The LF in (120), as we saw, means something else; it expresses a *de re* reading, which typically is false when (119) is uttered sincerely. So there must be another LF. What does it look like and how is it derived? One way to capture the intended reading, it seems, would be to generate an LF that's essentially the same as the underlying structure we posited for (119), i.e., the structure *before* the subject has raised:

- (123) [IP e [I' [must R] [somebody have-been-here]]]

(123) means precisely (122) (assuming that the unfilled Spec-of-IP position is semantically vacuous), as you can verify by calculating its interpretation by our rules. So is (123) (one of) the LF(s) for (119), and what assumption about syntax allow it to be generated? Or are there other – perhaps less obvious, but easier to generate – candidates for the *de dicto* LF-structure of (119)?

Before we get into these question, let's look at a few more examples. Each of the following sentences, we claim, has a *de dicto* reading for the subject, as given in the accompanying formula. The modal operators in the examples are of a variety of syntactic types, including modal auxiliaries, main verbs, adjectives, and adverbs.

- (124) Everyone in the class may have received an A.
 $\exists w'[w' \text{ conforms to what I believe in } w \ \&$
 $\forall x[x \text{ is in this class in } w' \rightarrow x \text{ received an A in } w']]$
- (125) At least two semanticists have to be invited.
 $\forall w'[w' \text{ conforms to what is desirable in } w$
 $\rightarrow \exists_2 x [x \text{ is a semanticist in } w' \ \& \ x \text{ is invited in } w']]$
- (126) Somebody from New York is expected to win the lottery.
 $\forall w'[w' \text{ conforms to what is expected in } w$
 $\rightarrow \exists x[x \text{ is a person from NY in } w' \ \& \ x \text{ wins the lottery in } w']]$

- (127) Somebody from New York is likely to win the lottery.
 $\forall w'[w' \text{ is as likely as any other world, given I know in } w$
 $\rightarrow \exists x[x \text{ is a person from NY in } w' \ \& \ x \text{ wins the lottery in } w']]$ ³
- (128) One of these two people is probably infected.
 $\forall w'[w' \text{ is as likely as any other world, given what I know in } w$
 $\rightarrow \exists x[x \text{ is one of these two people} \ \& \ x \text{ is infected in } w']]$

To bring out the intended *de dicto* reading of the last example (to pick just one) imagine this scenario: We are tracking a dangerous virus infection and have sampled blood from two particular patients. Unfortunately, we were sloppy and the blood samples ended up all mixed up in one container. The virus count is high enough to make it quite probable that one of the patients is infected but because of the mix-up we have no evidence about which one of them it may be. In this scenario, (128) appears to be true. It would not be true under a *de re* reading, because neither one of the two people is infected in every one of the likely worlds.

3 Hopefully the exact analysis of the modal operators *likely* and *probably* is not too crucial for the present discussion, but you may still be wondering about it. As you see in our formula, we are thinking of *likely* (*probably*) as a kind of epistemic necessity operator, i.e., a universal quantifier over a set of worlds that is somehow determined by the speaker's knowledge. (We are focussing on the "subjective probability" sense of these words. Perhaps there is also an "objective probability" reading that is circumstantial rather than epistemic.) What is the difference then between *likely* and e.g. epistemic *must* (or *necessary* or *I believe that*)? Intuitively, 'it is likely that p' makes a weaker claim than 'it must be the case that p'. If both are universal quantifiers, then, it appears that *likely* is quantifying over a smaller set than *must*, i.e., over only a proper subset of the worlds that are compatible with what I believe. The difference concerns those worlds that I cannot strictly rule out but regard as remote possibilities. These worlds are included in the domain for *must*, but not in the one for *likely*. For example, if there was a race between John and Mary, and I am willing to bet that Mary won but am not completely sure she did, then those worlds where John won are remote possibilities for me. They are included in the domain of *must*, and so I will not say that Mary *must* have won, but they are not in the domain quantified over by *likely*, so I do say that Mary is *likely* to have won.

This is only a very crude approximation, of course. For one thing, probability is a gradable notion. Some things are more probable than others, and where we draw the line between what's probable and what isn't is a vague or context-dependent matter. Even *must*, *necessary* etc. arguably don't really express complete certainty (because in practice there is hardly anything we are completely certain of), but rather just a very high degree of probability. For more discussion of *likely*, *necessary*, and other graded modal concepts in a possible worlds semantics, see e.g. Kratzer 1981, 1991.

A different approach may be that *likely* quantifies over the same set of worlds as *must*, but with a weaker, less than universal, quantificational force. I.e., 'it is likely that p' means something like p is true in *most* of the worlds conforming to what I know. A *prima facie* problem with this idea is that presumably every proposition is true in infinitely many possible worlds, so how can we make sense of cardinal notions like 'more' and 'most' here? But perhaps this can be worked out somehow.

A word of clarification about our empirical claim: We have been concentrating on the observation that *de dicto* readings are *available*, but have not addressed the question whether they are the *only* available readings or coexist with equally possible *de re* readings. Indeed, some of the sentences in our list appear to be ambiguous: For example, it seems that (126) could also be understood to claim that there is a particular New Yorker who is likely to win (e.g., because he has bribed everybody). Others arguably are not ambiguous and can only be read *de dicto*. This is what von Stechow & Iatridou [23] claim about sentences like (124). They note that if (124) also allowed a *de re* reading, it should be possible to make coherent sense of (129).

(129) Everyone in the class may have received an A. But not everybody did.

In fact, (129) sounds contradictory, which they show is explained if only the *de dicto* reading is permitted by the grammar. They conjecture that this is a systematic property of epistemic modal operators (as opposed to deontic and other types of modalities). Epistemic operators always have widest scope in their sentence.

So there are really two challenges here for our current theory. We need to account for the existence of *de dicto* readings, and also for the absence, in at least some of our examples, of *de re* readings. We will be concerned here exclusively with the first challenge and will set the second aside. We will aim, in effect, to set up the system so that all sentences of this type are in principle ambiguous, hoping that additional constraints that we are not investigating here will kick in to exclude the *de re* readings where they are missing.

To complicate the empirical picture further, there are also examples where raised subjects are unambiguously *de re*. Such cases have been around in the syntactic literature for a while, and they have recently received renewed attention in the work of Lasnik and others. To illustrate just one of the systematic restrictions, negative quantifiers like *nobody* seem to permit only surface scope (i.e., wide scope) with respect to a modal verb or adjective they have raised over.

(130) Nobody from New York is likely to win the lottery.

(130) does not have a *de dicto* reading parallel to the one for (127) above, i.e., it cannot mean that it is likely that nobody from NY will win. It can only mean that there is nobody from NY who is likely to win. This too is an issue that we set aside.

In the next couple of sections, all that we are trying to do is find and justify a mechanism by which the grammar is capable to generate both *de re* and *de dicto* readings for subjects that have raised over modal operators. It is quite

conceivable, of course, that the nature of the additional constraints which often exclude one reading or the other is ultimately relevant to this discussion and that a better understanding of them may undermine our conclusions. But this is something we must leave for further research.

6.2.2 Syntactic “Reconstruction”

Given that the *de dicto* reading of (119) we are aiming to generate is equivalent to the formula in (122), an obvious idea is that there is an LF which is essentially the pre-movement structure of this sentence, i.e., the structure prior to the raising of the subject above the operator. There are a number of ways to make such an LF available.

One option, most recently defended in Elbourne & Sauerland [18], is to assume that the raising of the subject can happen in a part of the derivation which only feeds PF, not LF. In that case, the subject simply stays in its underlying VP-internal position throughout the derivation from DS to LF. (Recall that quantifiers are interpretable there, as they generally are in subject positions.)

Another option is a version of the so-called Copy Theory of movement introduced in Chomsky [8]. This assumes that movement generally proceeds in two separate steps, rather than as a single complex operation as we have assumed so far. Recall that in H & K, it was stipulated that every movement effects the following four changes:

- (i) a phrase α is deleted,
- (ii) an index i is attached to the resulting empty node (making it a so-called trace, which the semantic rule for “Pronouns and Traces” recognizes as a variable),
- (iii) a new copy of α is created somewhere else in the tree (at the “landing site”), and
- (iv) the sister-constituent of this new copy gets another instance of the index i adjoined to it (which the semantic rule of Predicate Abstraction recognizes as a binder index).

If we adopt the Copy Theory, we assume instead that there are three distinct operations:

“Copy”: Create a new copy of α somewhere in the tree, attach an index i to the original α , and adjoin another instance of i to the sister of the new copy of α . (= steps (ii), (iii), and (iv) above)

“Delete Lower Copy”: Delete the original α . (= step (i) above)

“Delete Upper Copy”: Delete the new copy of α and both instances of i .

The Copy operation is part of every movement operation, and can happen anywhere in the syntactic derivation. The Delete operations happen at the end of the LF derivation and at the end of the PF deletion. We have a choice of applying either Delete Lower Copy or Delete Upper Copy to each pair of copies, and we can make this choice independently at LF and at PF. (E.g., we can do Copy in the common part of the derivation and then Delete Lower Copy at LF and Delete Upper Copy at PF.) If we always choose Delete Lower Copy at LF, this system generates exactly the same structures and interpretations as the one from H&K. But if we exercise the Delete Upper Copy option at LF, we are effectively undoing previous movements, and this gives us LFs with potentially new interpretations. In the application we are interested in here, we would apply the Copy step of subject raising before the derivation branches, and then choose Delete Lower Copy at PF but Delete Upper Copy at LF. The LF will thus look as if the raising never happened, and it will straightforwardly get the desired *de dicto* reading.

If the choice between the two Delete operations is generally optional, we in principle predict ambiguity wherever there has been movement. Notice, however, first, that the two structures will often be truth-conditionally equivalent (e.g. when the moved phrase is a name), and second, that they will not always be both interpretable. (E.g., if we chose Delete Upper Copy after QRing a quantifier from object position, we'd get an uninterpretable structure, and so this option is automatically ruled out.) Even so, we predict lots of ambiguity. Specifically, since raised subjects are always interpretable in both their underlying and raised locations, we predict all raising structures where a quantificational DP has raised over a modal operator (or over negation or a temporal operator) to be ambiguous. As we have already mentioned, this is not factually correct, and so there must be various further constraints that somehow restrict the choices. (Similar comments apply, of course, to the option we mentioned first, of applying raising only on the PF-branch.)

Yet another solution was first proposed by May [58]: May assumed that QR could in principle apply in a “downward” fashion, i.e., it could adjoin the moved phrase to a node that doesn't contain its trace. Exercising this option with a raised subject would let us produce the following structure, where the subject has first raised over the modal and then QRed below it.

(131) $t_j \lambda_i [\text{must-R} [\text{someone } \lambda_j [t_i \text{ have been here}]]]$

As it stands, this structure contains at least one free variable (the trace t_j) and can therefore not possibly represent any actual reading of this sentence. May further assumes that traces can in principle be deleted, when their presence is not required for interpretability. This is not yet quite enough, though to make (131) interpretable, at least not within our framework of assumptions, for (132)

is still not a candidate for an actual reading of (119).

(132) λ_i [must-R [someone λ_j [t_i have been here]]]

We would need to assume further that the topmost binder index could be deleted along with the unbound trace, and also that the indices i and j can be the same, so that the raising trace t_j is bound by the binding-index created by QR. If these things can be properly worked out somehow, then this is another way to generate the *de dicto* reading. Notice that the LF is not exactly the same as on the previous two approaches, since the subject ends up in an adjoined position rather than in its original argument position, but this difference is obviously without semantic import.

What all of these approaches have in common is that they place the burden of generating the *de dicto* reading for raised subjects on the syntactic derivation. Somehow or other, they all wind up with structures in which the subject is lower than it is on the surface and thereby falls within the scope of the modal operator. They also have in common that they take the modal operator (here the auxiliary, in other cases a main predicate or an adverb) to be staying put. I.e., they assume that the *de dicto* readings are not due to the modal operator being covertly higher than it seems to be, but to the subject being lower. Approaches with these features will be said to appeal to “syntactic reconstruction” of the subject.⁴

6.2.3 Some Alternatives to Syntactic Reconstruction

Besides (some version of) syntactic reconstruction, there are many other ways in which one try to generate *de dicto* readings for raised subjects. Here are some other possibilities that have been suggested and or readily come to mind. We will see that some of them yield exactly the *de dicto* reading as we have been describing it so far, whereas others yield a reading that is very similar but not quite the same. We will confine ourselves to analyses which involve no or only minor changes to our system of syntactic and semantic assumptions. Obviously, if departed from these further, there would be even more different options, but even so, there seem to be quite a few.

⁴ This is a very broad notion of “reconstruction”, where basically any mechanism which puts a phrase at LF in a location nearer to its underlying site than its surface site is called “reconstruction”. In some of the literature, the term is used more narrowly. For example, May’s downward QR is sometimes explicitly contrasted with genuine reconstruction, since it places the quantifier somewhere else than exactly where it has moved from.

1. RAISING THE MODAL OPERATOR, VARIANT 1: NO TRACE Conceivably, an LF for the *de dicto* reading of (119) might be derived from the S-structure (= (120)) by covertly moving *must* (and its covert *R*-argument) up above the subject. This would have to be a movement which leaves no (semantically non-vacuous) trace. Given our inventory of composition rules, the only type that the trace could have to make the structure containing it interpretable would be the type of the moved operator itself (i.e. $\langle st, t \rangle$). If it had that type, however, the movement would be semantically inconsequential, i.e., the structure would mean exactly the same as (120). So this would not be a way to provide an LF for the *de dicto* reading. If there was no trace left however (and also no binder index introduced), we indeed would obtain the *de dicto* reading.

EXERCISE 6.2: Prove the claims we just made in the previous paragraph. Why is no type for the trace other than $\langle st, t \rangle$ possible? Why is the movement semantically inert when this type is chosen? How does the correct intended meaning arise if there is no trace and binder index? \square

2. RAISING THE MODAL OPERATOR, VARIANT 2: TRACE OF TYPE S [Requires slightly modified inventory of composition rules. Derives an interpretation that is not quite the same as the *de dicto* reading we have assumed so far. Rather, it is a “narrow-Q, R-de-re” interpretation in the sense of Section ?? below.]

3. HIGHER TYPE FOR TRACE OF RAISING, VARIANT 1: TYPE $\langle et, t \rangle$ [Before reading this section, read and do the exercise on p.212/3 in H&K]

So far in our discussion, we have taken for granted that the LF which corresponds to the surface structure, viz. (120), gives us the *de re* reading. This, however, is correct only on the tacit assumption that the trace of raising is a variable of type *e*. If it is part of our general theory that all variables, or at least all interpretable binder indices (hence all bound variables), in our LFs are of type *e*, then there is nothing more here to say. But it is not *prima facie* obvious that we must or should make this general assumption, and if we don't, then the tree in (120) is not really one single LF, but the common structure for many different ones, which differ in the type chosen for the trace. Most of the infinitely many semantic types we might assign to this trace will lead to uninterpretable structures, but there turns out to be one other choice besides *e* that works, namely $\langle et, t \rangle$:

(133) somebody $\lambda_{2, \langle et, t \rangle}$ [[must R] [$t_{2, \langle et, t \rangle}$ have-been-here]]

(133) is interpretable in our system, but again, as above, the predicted interpretation is not exactly the *de dicto* reading as we have been describing it so far, but a “narrow-Q, R-de-re” reading.

EXERCISE 6.3: Using higher-type traces to “reverse” syntactic scope-relation is a trick which can be used quite generally. It is useful to look at a non-intensional example as a first illustration. (134) contains a universal quantifier and a negation, and it is scopally ambiguous between the readings in (a) and (b).

(134) Everything that glitters is not gold.

- | | | |
|----|--|-----------------|
| a. | $\forall x[x \text{ glitters} \rightarrow \neg x \text{ is gold}]$ | “surface scope” |
| b. | $\neg \forall x[x \text{ glitters} \rightarrow x \text{ is gold}]$ | “inverse scope” |

We could derive the inverse scope reading for (134) by generating an LF (e.g. by some version of syntactic reconstruction⁵) in which the *every*-DP is below *not*. Interestingly, however, we can also derive this reading if the *every*-DP is in its raised position above *not* but its trace has the type $\langle\langle e, t \rangle, t\rangle$.

Spell out this analysis. (I.e., draw the LF and show how the inverse-scope interpretation is calculated by our semantic rules.) \square

EXERCISE 6.4: Convince yourself that there are no other types for the raising trace besides e and $\langle et, t \rangle$ that would make the structure in (120) interpretable. (At least not if we stick exactly to our current composition rules.) \square

4. HIGHER TYPE FOR TRACE OF RAISING, VARIANT 2: TYPE $\langle s, \langle et, t \rangle \rangle$ If we want to get *exactly* the *de dicto* reading that results from syntactic reconstruction out of a surface-like LF of the form (120), we must use an even higher type for the raising trace, namely $\langle s, \langle\langle e, t \rangle, t \rangle \rangle$, the type of the intension of a quantifier. As you just proved in the exercise, this is not possible if we stick to exactly the composition rules that we have currently available. The problem is in the VP: the trace in subject position is of type $\langle s, \langle\langle e, t \rangle, t \rangle \rangle$ and its sister is of type $\langle e, t \rangle$. These two cannot combine by either FA or IFA, but it works if we employ another variant of functional application.⁵

(135) *Extensionalizing Functional Application* (EFA)

If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any

⁵ Notice that the problem here is kind of the mirror image of the problem that led to the introduction of “Intensional Functional Application” in H&K, ch. 12. There, we had a function looking for an argument of type $\langle s, t \rangle$, but the sister node had an extension of type t . IFA allowed us to, in effect, construct an argument with an added “ s ” in its type. This time around, we have to get rid of an “ s ” rather than adding one; and this is what EFA accomplishes.

So we now have three different “functional application”-type rules altogether in our system: ordinary FA simply applies $\llbracket \beta \rrbracket^w$ to $\llbracket \gamma \rrbracket^w$; IFA applies $\llbracket \beta \rrbracket^w$ to $\lambda w'. \llbracket \gamma \rrbracket^{w'}$; and EFA applies $\llbracket \beta \rrbracket^w(w)$ to $\llbracket \gamma \rrbracket^w$. At most one of them will be applicable to each given branching node, depending on the type of $\llbracket \gamma \rrbracket^w$.

Think about the situation. Might there be other variant functional application rules?

world w and assignment g :

if $\llbracket \beta \rrbracket^{w,g}(w)$ is a function whose domain contains $\llbracket \gamma \rrbracket^{w,g}$,

then $\llbracket \alpha \rrbracket^{w,g} = \llbracket \beta \rrbracket^{w,g}(w)(\llbracket \gamma \rrbracket^{w,g})$.

EXERCISE 6.5: Calculate the truth-conditions of (120) under the assumption that the trace of the subject quantifier is of type $\langle s, \langle \langle e, t \rangle, t \rangle \rangle$. \square

CAN WE CHOOSE BETWEEN ALL THESE OPTIONS? Two of the methods we tried derived readings in which the raised subject's *quantificational determiner* took scope below the world-quantifier in the modal operator, but the raised subject's *restricting NP* still was evaluated in the utterance world (or the evaluation world for the larger sentence, whichever that may be). It is difficult to assess whether these readings are actually available for the sentences under consideration, and we will postpone this question to a later section. We would like to argue here, however, that even if these readings are available, they cannot be the *only* readings that are available for raised subjects besides their wide-scope readings. In other words, even if we allowed one of the mechanisms that generated these sort of hybrid readings, we would still need another mechanism that gives us, for at least some examples, the “real” *de dicto* readings that we obtain e.g. by syntactic reconstruction. The relevant examples that show this most clearly involve DPs with more descriptive content than *somebody* and whose NPs express clearly contingent properties.

(136) A neat-freak must have been here.

If I say this instead of our original (119) when I come to my office in the morning and interpret the clues on my desk, I am saying that every world compatible with my beliefs is such that someone who is a neat-freak *in that world* was here in that world. Suppose there is a guy, Bill, whom I know slightly but not well enough to have an opinion on whether or not he is neat. He may or not be, for all I know. So there are worlds among my belief worlds where he is a neat-freak and worlds where he is not. I also don't have an opinion on whether he was or wasn't the one who came into my office last night. He did in some of my belief worlds and he didn't in others. I am implying with (136), however, that if Bill isn't a neat-freak, then it wasn't him in my office. I.e., (136) *is* telling you that, even if I have belief-worlds in which Bill is a slob and I have belief-worlds in which (only) he was in my office, I do not have any belief-worlds in which Bill is a slob *and* the only person who was in my office. This is correctly predicted if (136) expresses the “genuine” *de dicto* reading in (137), but not if it expresses the “hybrid” reading in (138).

(137) $\forall w'[w' \text{ is compatible with what I believe in } w_0 \rightarrow \exists x[x \text{ is a neatfreak in } w' \text{ and } x \text{ was here in } w']]$

- (138) $\forall w'[w' \text{ is compatible with what I believe in } w_0 \rightarrow \exists x[x \text{ is a neatfreak in } w_0 \text{ and } x \text{ was here in } w']]$

We therefore conclude the mechanisms 2 and 3 considered above (whatever there merits otherwise) cannot supplant syntactic reconstruction or some other mechanism that yields readings like (137).

This leaves only the first and fourth options that we looked at as potential competitors to syntactic reconstruction, and we will focus the rest of the discussion on how we might be able to tease apart the predictions that these mechanisms imply from the ones of a syntactic reconstruction approach.

As for moving the modal operator, there are no direct bad predictions that we are aware of with this. But it leads us to expect that we might find not only scope ambiguities involving a modal operator and a DP, but also scope ambiguities between two modal operators, since one of them might covertly move over the other. It seems that this never happens. Sentences with stacked modal verbs seem to be unambiguous and show only those readings where the scopes of the operators reflect their surface hierarchy.

- (139) a. I have to be allowed to graduate.
b. #I am allowed to have to graduate.

Of course, this might be explained by appropriate constraints on the movement of modal operators, and such constraints may even come for free in a the right syntactic theory. Also, we should have a much more comprehensive investigation of the empirical facts before we reach any verdict. If it is true, however, that modal operators only engage in scope interaction with DPs and never with each other, then a theory which does not allow any movement of modals at all could claim the advantage of having a simple and principled explanation for this fact.

What about the “semantic reconstruction” option, where raised subjects can leave traces of type $\langle s, \langle et, t \rangle \rangle$ and thus get narrow scope semantically without ending up low syntactically? This type of approach has been explored quite thoroughly and defended with great sophistication. We can only sketch the main objections to it here and must leave it to the reader to consult the literature for an informed opinion.

SCOPE RECONSTRUCTION AND CONDITION C An example from Fox (1999) (building on Lebeaux 1994 and Heycock 1995):

- (140) a. A student of his_i seems to David_i to be at the party.
b. A student of David's_i seems to him_i to be at the party.

^{OK}*de re*, ^{OK}*de dicto*

^{OK} *de re*, **de dicto*

Sketch of argument: If Cond. C is formulated in terms of c-command relations and applies at LF, it will distinguish between *de re* and *de dicto* readings only if those involve LFs with different hierarchical relations.

RAISING OF IDIOM CHUNKS

(141) The cat seems to be out of the bag.

(142) ?Advantage might have been taken of them.

Sketch of argument: If idioms must be constituents at LF in order to receive their idiomatic interpretations, these cases call for syntactic reconstruction. An additional mechanism of semantic reconstruction via high-type traces is then at best redundant.

Tentative conclusion: Syntactic reconstruction (some version of it) provides the best account of *de dicto* readings for raised subjects.

- [1] BARWISE, John & COOPER, Robin: 1981. "Generalized Quantifiers and Natural Language." *Linguistics & Philosophy*, 4: 159–219.
- [2] BENNETT, Jonathan: 2003. *A Philosophical Guide to Conditionals*. Oxford University Press.
- [3] BHATT, Rajesh: 1997. "Obligation and Possession." In Heidi Harley (Editor) *Papers from the UPenn/MIT Roundtable on Argument Structure and Aspect*, volume 32 of *MIT Working Papers in Linguistics*. MIT Working Papers in Linguistics.
- [4] BHATT, Rajesh & PANCHEVA, Roumyana: 2001. "Conditionals." URL <http://www-rcf.usc.edu/~pancheva/cond.pdf>.
- [5] BONOMI, Andrea & ZUCCHI, Sandro: 2003. "A Pragmatic Framework for Truth in Fiction." *Dialectica*, 57(2): 103–120. Preprint <http://filosofia.dipafilo.unimi.it/~zucchi/NuoviFile/Bonomi%26Zucchio3.pdf.zip>.
- [6] BUTLER, Jonny: 2003. "A Minimalist Treatment of Modality." *Lingua*, 113(10): 967–996. doi:10.1016/S0024-3841(02)00146-8. Preprint <http://www-users.york.ac.uk/~jrcb100/minimalist-modality.pdf>.
- [7] CHIERCHIA, Gennaro & MCCONNELL-GINET, Sally: 2000. *Meaning and Grammar: An Introduction to Semantics (2nd Edition)*. MIT Press.
- [8] CHOMSKY, Noam: 1993. "A Minimalist Program for Linguistic Theory." In Kenneth Hale & Samuel Jay Keyser (Editors) *The View from Building 20: Essays in Linguistics in Honor of Sylvain Bromberger*, pages 1–52. MIT Press Cambridge, MA.
- [9] COPELAND, B. Jack: 2002. "The Genesis of Possible Worlds Semantics." *Journal of Philosophical Logic*, 31(2): 99–137. doi:10.1023/A:1015273407895.
- [10] CORMACK, Annabel & SMITH, Neil: 2002. "Modals and negation in English." In Sjef Barbiers, Frits Beukema, & Wim van der Wurff (Editors) *Modality and its Interaction with the Verbal System*, pages 133–163. Benjamins.
- [11] CRESSWELL, Max: 1973. *Logics and Languages*. London: Methuen.

- [12] DEROSE, Keith: 1991. "Epistemic Possibilities." *The Philosophical Review*, 100(4): 581–605.
- [13] DOWTY, David: 1982. "Tenses, Time Adverbs, and Compositional Semantic Theory." *Linguistics and Philosophy*, 5: 23–55.
- [14] DOWTY, David, WALL, Robert, & PETERS, Stanley: 1981. *Introduction to Montague Semantics*. Kluwer.
- [15] EDGINGTON, Dorothy: 1995. "On Conditionals." *Mind*, 104: 235–329.
- [16] EGAN, Andy: 2004. "Epistemic Modals, Relativism and Assertion." URL <http://www.geocities.com/eganamit/might.doc>. Ms.
- [17] EGAN, Andy, HAWTHORNE, John, & WEATHERSON, Brian: 2003. "Epistemic Modals in Context." URL <http://brian.weatherson.net/em.pdf>.
- [18] ELBOURNE, Paul & SAUERLAND, Uli: 2002. "Total Reconstruction, PF Movement, and Derivational Order." *Linguistic Inquiry*, 33(2): 283–319.
- [19] VON FINTEL, Kai: 1999. "NPI Licensing, Strawson Entailment, and Context Dependency." *Journal of Semantics*, 16(2): 97–148. URL http://www3.oup.co.uk/semant/hdb/Volume_16/Issue_02/160097.sgm.abs.html. Preprint: <http://web.mit.edu/fintel/www/npi.pdf>.
- [20] VON FINTEL, Kai: 2001. "Counterfactuals in a Dynamic Context." In Michael Kenstowicz (Editor) *Ken Hale: A Life in Language*, pages 123–152. MIT Press Cambridge, MA. Preprint version: <http://web.mit.edu/fintel/www/conditional.pdf>.
- [21] VON FINTEL, Kai & GILLIES, Anthony S.: 2005. "Might Made Right." URL <http://mit.edu/fintel/www/might.pdf>. Ms.
- [22] VON FINTEL, Kai & IATRIDOU, Sabine: 2002. "If and When *If*-Clauses Can Restrict Quantifiers." URL <http://web.mit.edu/fintel/www/lpw.mich.pdf>. Unpublished ms, MIT, contribution to the Workshop in Linguistics & Philosophy at the University of Michigan, November 8–10, 2002.
- [23] VON FINTEL, Kai & IATRIDOU, Sabine: 2003. "Epistemic Containment." *Linguistic Inquiry*, 34(2): 173–198. doi:10.1162/00243890321663370. Offprint: <http://web.mit.edu/fintel/www/ec.pdf>.
- [24] VON FINTEL, Kai & IATRIDOU, Sabine: 2004. "What to Do If You Want to Go to Harlem: Notes on Anankastic Conditionals and Related Matters." <http://web.mit.edu/fintel/www/harlem.pdf>.

- [25] FRANK, Anette: 1996. *Context Dependence in Modal Constructions*. Ph.D. thesis, Universität Stuttgart. URL <http://www.dfki.de/~frank/papers/header.ps.gz>.
- [26] GAMUT, L. T. F.: 1991. *Logic, Language, and Meaning*. Chicago University Press.
- [27] GARSON, James: Winter 2003. "Modal Logic." In Edward N. Zalta (Editor) *The Stanford Encyclopedia of Philosophy*. URL <http://plato.stanford.edu/archives/win2003/entries/logic-modal/>.
- [28] GEURTS, Bart: 1998. "Presuppositions and Anaphors in Attitude Contexts." *Linguistics & Philosophy*, 21(6): 545–601. doi:10.1023/A:1005481821597.
- [29] GIANNAKIDOU, Anastasia: 1999. "Affective Dependencies." *Linguistics & Philosophy*, 22(4): 367–421. doi:10.1023/A:1005492130684.
- [30] HEIM, Irene: 1992. "Presupposition Projection and the Semantics of Attitude Verbs." *Journal of Semantics*, 9: 183–221.
- [31] HEIM, Irene & KRATZER, Angelika: 1998. *Semantics in Generative Grammar*. Blackwell.
- [32] HERZBERGER, Hans: 1979. "Counterfactuals and Consistency." *Journal of Philosophy*, 76: 83–88.
- [33] HINTIKKA, Jaako: 1969. "Semantics for Propositional Attitudes." In J.W. Davis, D.J. Hockney, & W.K. Wilson (Editors) *Philosophical Logic*, pages 21–45. Dordrecht: Reidel.
- [34] HOCKETT, Charles F.: 1960. "The origin of speech." *Scientific American*, 203: 89–96.
- [35] HOCKETT, Charles F. & ALTMANN, Stuart A.: 1968. "A note on design features." In Thomas A. Sebeok (Editor) *Animal Communication: Techniques of Study and Results of Research*, pages 61–72. Indiana University Press.
- [36] HORN, Laurence R.: 1972. *On the Semantic Properties of the Logical Operators in English*. Ph.D. thesis, UCLA.
- [37] HUGHES, George & CRESWELL, Max: 1996. *A New Introduction to Modal Logic*. Routledge London.
- [38] IATRIDOU, Sabine: 2000. "The Grammatical Ingredients of Counterfactuality." *Linguistic Inquiry*, 31(2): 231–270. doi:10.1162/002438900554352.

- [39] IPPOLITO, Michela: 2003. "Presuppositions and Implicatures in Counterfactuals." *Natural Language Semantics*, 11(2): 145–186. doi:10.1023/A:1024411924818.
- [40] JACKSON, Frank: 1987. *Conditionals*. Oxford: Blackwell.
- [41] KADMON, Nirit & LANDMAN, Fred: 1993. "Any." *Linguistics & Philosophy*, 16: 353–422.
- [42] KNUUTTILA, Simo: 2003. "Medieval Theories of Modality." In Edward N. Zalta (Editor) *The Stanford Encyclopedia of Philosophy*. Center for the Study of Language and Information. URL <http://plato.stanford.edu/archives/fall2003/entries/modality-medieval/>.
- [43] KRATZER, Angelika: 1977. "What *Must* and *Can* Must and Can Mean." *Linguistics & Philosophy*, 1: 337–355.
- [44] KRATZER, Angelika: 1978. *Semantik der Rede: Kontexttheorie - Modalwörter - Konditionalsätze*. Königstein/Taunus: Scriptor.
- [45] KRATZER, Angelika: 1981. "The Notional Category of Modality." In H. J. Eikmeyer & H. Rieser (Editors) *Words, Worlds, and Contexts. New Approaches in Word Semantics*, pages 38–74. de Gruyter.
- [46] KRATZER, Angelika: 1986. "Conditionals." *Chicago Linguistics Society*, 22(2): 1–15. Reprinted in [74], pages 651–656.
- [47] KRATZER, Angelika: 1991. "Modality." In Arnim von Stechow & Dieter Wunderlich (Editors) *Semantik: Ein internationales Handbuch der zeitgenössischen Forschung*, pages 639–650. Walter de Gruyter Berlin.
- [48] KRIPKE, Saul: 1980. *Naming and Necessity*. Blackwell.
- [49] LEWIS, David: 1970. "General Semantics." *Synthese*, 22: 18–67. Reprinted with a postscript in Lewis [54], pp. 189–232.
- [50] LEWIS, David: 1973. *Counterfactuals*. Oxford: Blackwell.
- [51] LEWIS, David: 1975. "Adverbs of Quantification." In Edward Keenan (Editor) *Formal Semantics of Natural Language*, pages 3–15. Cambridge University Press.
- [52] LEWIS, David: 1978. "Truth in Fiction." *American Philosophical Quarterly*, 15: 37–46. Reprinted with postscripts in Lewis [54], pp. 261–280.
- [53] LEWIS, David: 1982. "Logic for Equivocators." *Noûs*, 16: 431–441. Reprinted in Lewis [56: pp. 97–110].

- [54] LEWIS, David: 1983. *Philosophical Papers: Volume 1*. Oxford University Press.
- [55] LEWIS, David: 1986. *On the Plurality of Worlds*. Oxford: Blackwell.
- [56] LEWIS, David: 1998. *Papers in Philosophical Logic*. Cambridge University Press.
- [57] MACFARLANE, John: 2003. "Epistemic Modalities and Relative Truth." URL <http://socrates.berkeley.edu/~jmacf/epistmod.pdf>.
- [58] MAY, Robert: 1977. *The Grammar of Quantification*. Ph.D. thesis, Massachusetts Institute of Technology.
- [59] MONTAGUE, Richard: 1973. "The Proper Treatment of Quantification in Ordinary English." In Jaako Hintikka, Julius Moravcsik, & Patrick Suppes (Editors) *Approaches to Natural Language*, pages 221–242. Reidel. Reprinted in Portner & Partee [66], pp. 17–34.
- [60] NUTE, Donald: 1984. "Conditional Logic." In Dov Gabbay & Franz Guenther (Editors) *Handbook of Philosophical Logic. Volume II*, pages 387–439. Dordrecht: Reidel.
- [61] PARTEE, Barbara H.: 2003. "Reflections of a Formal Semanticist." In *Compositionality in Formal Semantics: Selected Papers*. Blackwell. URL <http://www.blackwellpublishing.com/book.asp?ref=1405109343>.
- [62] PARTEE, Barbara H. & HENDRIKS, Herman L.W.: 1997. "Montague Grammar." In Johan van Benthem & Alice ter Meulen (Editors) *Handbook of Logic and Language*, pages 5–91. Amsterdam: Elsevier.
- [63] PERRY, John R.: 1998. "Semantics, possible worlds." In E. Craig (Editor) *Routledge Encyclopedia of Philosophy*. London: Routledge. URL <http://www.rep.routledge.com/article/U039>. Preprint <http://www-csli.stanford.edu/~john/PHILPAPERS/posswwld.pdf>.
- [64] POLLOCK, John: 1976. *Subjunctive Reasoning*. Reidel Dordrecht.
- [65] PORTNER, Paul: 1997. "The Semantics of Mood, Complementation, and Conversational Force." *Natural Language Semantics*, 5(2): 167–212. doi:10.1023/A:1008280630142.
- [66] PORTNER, Paul & PARTEE, Barbara H. (Editors) : 2002. *Formal Semantics: The Essential Readings*. Oxford: Blackwell.
- [67] PRIOR, A. N.: 1958. "Escapism: The Logical Basis of Ethics." In A. I. Melden (Editor) *Essays in Moral Philosophy*, pages 135–146. Seattle: University of Washington Press.

- [68] RUSSELL, Bertrand: 1940. *An Inquiry into Meaning and Truth*. London: George Allen and Unwin.
- [69] STALNAKER, Robert: 1968. "A Theory of Conditionals." In Nicholas Rescher (Editor) *Studies in Logical Theory*, pages 98–112. Oxford: Blackwell.
- [70] STALNAKER, Robert: 1975. "Indicative Conditionals." *Philosophia*, 5: 269–286.
- [71] STALNAKER, Robert: 1984. *Inquiry*. MIT Press.
- [72] STALNAKER, Robert: 1999. *Context and Content*. Oxford: Oxford University Press.
- [73] STANLEY, Jason & SZABÓ, Zoltán: 2000. "On Quantifier Domain Restriction." *Mind and Language*, 15(2/3): 219–261. URL <http://www.blackwell-synergy.com/links/doi/10.1111/1468-0017.00130/abs/>.
- [74] VON STECHOW, Arnim & WUNDERLICH, Dieter (Editors) : 1991. *Semantics: An International Handbook of Contemporary Research*. de Gruyter.
- [75] SUBER, Peter: 1997. "Paradoxes of Material Implication." URL <http://www.earlham.edu/~peters/courses/log/mat-imp.htm>.
- [76] VARZI, Achille: 1997. "Inconsistency without Contradiction." *Notre Dame Journal of Formal Logic*, 38(4): 621–638. Preprint http://www.columbia.edu/~av72/papers/Ndjfl_1997.pdf.
- [77] WARMBROD, Ken: 1982. "A Defense of the Limit Assumption." *Philosophical Studies*, 42: 53–66.
- [78] WURMBRAND, Susi: 1999. "Modal Verbs Must Be Raising Verbs." *West Coast Conference on Formal Linguistics (WCCFL)*, 18: 599–612. Preprint <http://www.arts.mcgill.ca/programs/linguistics/faculty/wurmbrand/research/files/WCCFL18.pdf>.