Intensional Semantics

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About these lecture notes

These lecture notes have been evolving for years now, starting with some old notes from the early 1990s by Angelika Kratzer, Irene Heim, and Kai von Fintel, which have since been modified and expanded many times by Irene and/or Kai.

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, and advice on these materials.

Link to the latest full version (currently the 2011 edition):

http://kvf.me/intensional

GitHub repository with the current development version:

https://github.com/fintelkai/fintel-heim-intensional-notes

Homepage of the class these notes are designed for:

http://stellar.mit.edu/S/course/24/sp16/24.973

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Some advice

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 at all anticipate doing semantics-related work in the future.
3. 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* would teach this material.

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Contents

Chapter One
Beginnings

Language is the main instrument
of man's refusal to accept the world
as it is.

George Steiner, *After Babel*, p. 228

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.

1.1 Displacement

Hockett (1960) in a famous article (and a follow-up, Hockett & Altmann (1968)) 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

Charles F. Hockett. 1960. The origin of speech. *Scientific American* 203. 89–96 features is DISPLACEMENT. Human language is not restricted to discourse about the *actual here and now*.[1]

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:

The terms MODAL and MODALITY descend from the Latin *modus*, "way", and are ancient terms pertaining to the way a proposition holds, necessarily, contingently, etc.

(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.

See Kratzer (1981, 1991) for more examples of modal constructions.

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.

1 Steiner (1998, p. 226) writes: "Hypotheticals, 'imaginaries', conditionals, the syntax of counterfactuality and contingency may well be the generative centres of human speech".

(8) Habituals
Jane smokes.

(9) Generics
Bears like honey.

In this chapter, we will put in place the basic framework of intensional semantics, the kind of semantics that models displacement of the point of evaluation in temporal and modal dimensions. To do this, we will start with one rather special example of modal displacement:

https://en.wikipedia.org/wiki/Sherlock_Holmes

(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?

To make displacement possible and compositionally tractable, we need meanings of natural language expressions, and of sentences in particular, to be displaceable in the first place. They need to be "portable", so to speak, able to make claims about more than just the actual here and now. And need we need other natural language expressions that take that portable meaning and apply it to some situation other than the actual here and now. That is what intensionality is all about.

The basic idea of the account we'll develop is this:

- expressions are assigned their semantic values relative to a possible world;
- in particular, sentences have truth-values in possible worlds;
- in the absence of modal displacement, we evaluate sentences with respect to the "actual" world, the world in which we are speaking;
- modal displacement changes the world of evaluation;
- displacement is effected by special operators, whose semantics is our primary concern here.

A terminological note: we will call the sister of the intensional operator its prejacent, a useful term introduced by our medieval colleagues.

1.2 An Intensional Semantics in 10 Easy Steps

1.2.1 Laying the Foundations

David Lewis

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 D. Lewis (1986, 1f.):

> 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 worlds 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:[2]

(11) 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 assignment 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: $[\![\cdot]\!]^{w,g}$.

So, the prejacent embedded in (10) will have its truth-conditions described as follows:[3]

(12) $[\![\text{a famous detective lives at 221B Baker Street}]\!]^{w,g} = 1$
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

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

3 Recall from H&K, pp.22f, that what's inside the interpretation brackets is a mention of an object language expression. They make this clear by bold-facing all object language expressions inside interpretation brackets. In these notes, we will follow common practice in the field and not use a special typographic distinction, but let it be understood that what is interpreted are object language expressions.

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. $[\![\text{famous}]\!]^{w,g} = \lambda x \in D.\ x$ is famous in w.[4,5]
b. $[\![\text{detective}]\!]^{w,g} = \lambda x \in D.\ x$ is a detective in w.
c. $[\![\text{lives-at}]\!]^{w,g} = \lambda x \in D.\ \lambda y \in D.\ y$ lives-at x 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. $[\![\text{and}]\!]^{w,g} = \lambda u \in D_t.\ \lambda v \in D_t.\ u = v = 1.$
b. $[\![\text{the}]\!]^{w,g} = \lambda f \in D_{\langle e,t\rangle}\colon \exists! x[f(x) = 1].$ the y such that $f(y) = 1$.
c. $[\![\text{every}]\!]^{w,g} = \lambda f_{\langle e,t\rangle}.\ \lambda h_{\langle e,t\rangle}.\ \forall x_e\colon f(x) = 1 \rightarrow h(x) = 1.$
d. $[\![\text{a/some}]\!]^{w,g} = \lambda f_{\langle e,t\rangle}.\ \lambda h_{\langle e,t\rangle}.\ \exists x_e\colon f(x) = 1\ \&\ h(x) = 1.$

Note the ruthless condensation of the notation in (c) and (d): variables are subscripted with the type of the domain that their values are constrained to come from.

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. $[\![\text{Noam Chomsky}]\!]^{w,g}$ = Noam Chomsky.

4 Of course, "$\lambda x \in D.\ \dots$" is short for "$\lambda x\colon x \in D.\ \dots$". Get used to semanticists condensing their notation whenever convenient! A further step of condensation is taken below: "$\lambda x\colon x \in D_e.\ \dots$" becomes "$\lambda x_e.\ \dots$".

5 Always make sure that you actually understand what the notation means. Here, for example, we are saying that the semantic value of the word *famous* with respect to a given possible world w and a variable assignment g is that function that is defined for an argument x only if x is a member of the domain of individuals and that, if it is defined, yields the truth-value 1 if and only if x is famous in w.

b. $[\![\text{Sherlock Holmes}]\!]^{w,g}$ = Sherlock Holmes.
c. $[\![\text{221B Baker Street}]\!]^{w,g}$ = 221B 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 them by adding 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 $[\![\beta]\!]^{w,g}$ is a function whose domain contains $[\![\gamma]\!]^{w,g}$, then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}([\![\gamma]\!]^{w,g})$.

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. We first adopt the "Appropriateness Condition" from Heim & Kratzer (p.243):

(17) APPROPRIATENESS CONDITION
A context c is *appropriate* for an LF ϕ only if c determines a variable assignment g_c whose domain includes every index which has a free occurrence in ϕ.

We then intensionalize Heim & Kratzer's definition of truth and falsity of utterances:

(18) TRUTH AND FALSITY CONDITIONS FOR UTTERANCES
An utterance of a sentence ϕ in a context c in a possible world w is *true* iff $[\![\phi]\!]^{w,g_c} = 1$ and *false* if $[\![\phi]\!]^{w,g_c} = 0$.

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 excrutiating detail, not skipping any steps.] □

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 mentioned that there are 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:

(19) $[\![$in the world of Sherlock Holmes,
a famous detective lives at 221B Baker Street$]\!]^{w,g} = 1$
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 had this rule for *in the world of Sherlock Holmes*:

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

This is a so-called syncategorematic treatment of the meaning of this expression. Instead of giving an explicit semantic value to the expression, we specify what effect it has on the meaning of a complex expression that contains it. In (20), 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 syncategorematic semantics for the 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.

The diamond $\Diamond$ symbol for possibility is due to C.I. Lewis, first introduced in C. I. Lewis & Langford (1932), but he made no use of a symbol for the dual combination $\neg\Diamond\neg$. The dual symbol $\Box$ was later devised by F.B. Fitch and first appeared in print in 1946 in a paper by his doctoral student Barcan (1946). See footnote 425 of Hughes & M.J. Cresswell (1968). Another notation one finds is L for necessity and M for possibility, the latter from the German *möglich* 'possible'.

So, we want to give *in the world of Sherlock Holmes* its own meaning and combine that meaning with that of its prejacent 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).[6] So, what we will want to do is to make (19) 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

6 See Heim & Kratzer, Section 4.3, pp. 63–72 for a reminder about the status of predicate modification.

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 prejacent. Can we do this?

Exercise 1.2: How would you show that *in the world of Sherlock Holmes* is not a truth-functional operator? □

Step 7: Intensions. We will define a richer notion of semantic value, the intension of an expression. This will be a function from possible worlds to the extension of the expression in that world. The intension of a sentence can be applied to any world and give the truth-value of the sentence in that world. Intensional operators take the intension of their prejacent as their argument, that is we will feed the intension of the embedded sentence to the shifting operator. The operator will use that intension and apply it to the world it wants the evaluation to happen in. Voilà.

Now let's spell that account out. Our system actually provides us with two kinds of meanings. For any expression α, we have $[\![\alpha]\!]^{w,g}$, the semantic value of α in w, also known as the extension of α in w. But we can also calculate $\lambda w.[\![\alpha]\!]^{w,g}$, 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 notation[7] for the intension of α:

As before in H&K, we make no claim that the semantic values that are attributed to expressions in our framework fully capture what is informally meant by "meaning". But certainly, intensions come close to "meaning" than extensions.

(21) $[\![\alpha]\!]^{g}_{¢} := \lambda w.[\![\alpha]\!]^{w,g}$.

It should be immediately obvious that since the definition of intension abstracts over the evaluation world, intensions are not world-dependent.[8,9]

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

7 The notation with the subscripted cent-sign comes from Montague Grammar. See e.g. D. Dowty, Wall & Peters (1981, p. 147).

8 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 "$[\![\ldots]\!]^{w,g}_{¢}$"; we'll treat that as undefined nonsense.

9 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: $[\![\alpha]\!]^{g}_{¢} := \lambda w\colon\ \alpha \in \mathrm{dom}([\![]\!]^{w,g}).[\![\alpha]\!]^{w,g}$.

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.[10]

The Port-Royal logicians distinguished EXTENSION from COMPREHENSION. Leibniz preferred the term INTENSION rather than COMPREHENSION. The notion probably goes back even further. See Spencer (1971) for some notes on this. The possible worlds interpretation is due to Carnap (1947).

STEP 8: SEMANTIC TYPES AND SEMANTICS DOMAINS. 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 add a new clause, (22c), to the definition of semantic types:

(22) SEMANTIC TYPES
a. e and t are semantic types.
b. If σ and τ are semantic types, then $\langle \sigma, \tau \rangle$ is a semantic type.
c. If σ is a semantic type, then $\langle s, \sigma \rangle$ is a semantic type.
d. Nothing else is a semantic type.

We also add a fourth clause to the previous definition of semantic domains:

(23) SEMANTIC DOMAINS
a. $\mathrm{D}_e = \mathrm{D}$, the set of all possible individuals
b. $\mathrm{D}_t = \{0, 1\}$, the set of truth-values
c. If σ and τ are semantic types, then $\mathrm{D}_{\langle \sigma,\tau \rangle}$ is the set of all functions from D_σ to D_τ.
d. INTENSIONS: If σ is a type, then $\mathrm{D}_{\langle s,\sigma \rangle}$ is the set of all functions from W to D_σ.

Clause (d) is the addition to our previous system of types. The functions of the schematic type $\langle s, \ldots \rangle$ are intensions.[11] Here are some examples of intensions:

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10 For example, Frege's "modes of presentation" are not obviously captured by this possible worlds implementation of extension/intension.

11 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

- 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, that is functions that 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 (at least in the analysis sketched in Heim & Kratzer) 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 lexical entry for *in the world of Sherlock Holmes*:[12]

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

That is, *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.

(25) 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 $[\![\beta]\!]^{w,g}$ is a function whose domain contains $[\![\gamma]\!]^{g}_{¢}$, then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}([\![\gamma]\!]^{g}_{¢})$.

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actually question this assumption in a later chapter. For now, we will stay with this more conventional set-up.

12 This is not yet the final semantics, see Section 1.3 for complications. One complication we will not even start to discuss is that obviously it is not a necessity that there are Sherlock Holmes stories in the first place and that the use of this operator *presupposes* that they exist; so a more fully explicit semantics would need to build in that presuppositional component. Also, note again the condensed notation: "$\lambda p_{\langle s,t\rangle}.\ \dots$" stands for the fully official "$\lambda p\colon\ p \in D_{\langle s,t\rangle}.\ \dots$".

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 (24), 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 prejacent in various possible worlds. To see in practice that we have all we need, please do the following exercise.

Exercise 1.3: 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. □

Exercise 1.4: What in our system prevents us from computing the extension of *Watson is slow*, for example, by applying the intension of *slow* to the extension of *Watson*? What in our system prevents us from computing the extension of *Watson is slow* by applying the intension of *slow* to the intension of *Watson*? □

Please think about this exercise before looking at Section 1.4, which explores this issue.

Exercise 1.5: What is wrong with the following equation:

(26) $(\lambda x.\ x \text{ is slow in } w)$ (Watson) = Watson is slow in w.

[Hint: there is nothing wrong with the following:

(27) $(\lambda x.\ x \text{ is slow in } w)$ (Watson) = 1 iff Watson is slow in w.] □

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.

Exercise 1.6: Consider the following “intensional” meaning for *and*:

(28) $[\![\text{and}]\!]^{w,g} = \lambda p_{\langle s,t\rangle}.\ \lambda q_{\langle s,t\rangle}.\ p(w) = q(w) = 1.$

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? □

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 D. Lewis 1970, Max Cresswell 1973).

(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*:

(29) $[\![\text{in the world of Sherlock Holmes}]\!]^{w,g} =$
$\lambda p_{\langle s,t\rangle}$. the world w' as it is described in the Sherlock Holmes stories 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 no-matter-what or false no-matter-what. 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:

(30) $[\![\text{in the world of Sherlock Holmes}]\!]^{w,g} =$
$\lambda p_{\langle s,t \rangle}$. the world w' as it is described in the Sherlock Holmes stories *in* w 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:

(31) 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. D. Lewis (1978) 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 explanation of that is that the world*s* 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:

(32) $[\![\text{in the world of Sherlock Holmes}]\!]^{w,g} =$
$\lambda p_{\langle s,t\rangle}.\ \forall w'$ compatible with the Sherlock Holmes stories *in* w:
$p(w') = 1.$

At a very abstract level, the way we parse sentences of the form *in the world of Sherlock Holmes,* ϕ is that both components, the *in*-phrase and the prejacent, determine sets of possible worlds and that the set of possible worlds representing the content of the fiction mentioned in the *in*-phrase is a subset of the set of possible worlds determined by the prejacent. We will see the same rough structure of relating sets of possible worlds in other intensional constructions.

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, for our purposes we're done with this kind of operator.

1.4 *Issues with an informal meta-language

Exercise 1.5 asks what is wrong with writing something like[13]

Starred sections are optional on a first pass.

(33) (λx. x is slow in w) (Watson) = Watson is slow in w.

Think about it. On the left hand side of the "=" sign is a meta-language expression consisting of a λ-expression (so some kind of function) applied to an individual (contributed by the meta-language name "Watson"). The function is a function from individuals to truth-values that will deliver the truth-value 1 iff the individual is slow in world w. So, what we have on the left hand side is the result of a function from individuals to truth-values applied to an individual. In other words, on the left hand side we have a truth-value, namely the truth-value 1 if Watson is slow in w and the truth-value 0 if Watson is not slow in w.

13 Thanks to Magda Kaufmann, Angelika Kratzer, and Ede Zimmermann for discussion on the issues explored in this section.

Now, what do we have on the right hand side of the "="? We have the meta-language sentence "Watson is slow in w". That is not nor does it contribute a truth-value. It is a statement of fact. Truth-values are not the same as statements of fact.

The proper thing to do is to write

(34) $(\lambda x.\ x \text{ is slow in } w)(\text{Watson}) = 1$ iff Watson is slow in w.

There are actually two ways to parse the statement in (34), both legitimate it appears.

On one parse, the major connective is the meta-language expression "iff". On its left hand side is a meta-language statement (that applying the function to the individual Watson gives the truth-value 1) and on the right hand side of the "iff" we have another meta-language statement (that Watson is slow in w). So, the whole thing says that these two statements are equivalent: (i) that function applied to that individual gives us the truth-value 1, and (ii) that Watson is slow in w.

The other parse is perhaps more conspicuously represented as follows:

(35) $$(\lambda x.\ x \text{ is slow in } w)(\text{Watson}) = \begin{cases} 1 \text{ if Watson is slow in } w \\ 0 \text{ if Watson is not slow in } w \end{cases}$$

Here, the "=" sign is the major connective. The left hand side is a meta-language expression that resolves to a truth-value and the right hand side as well contributes a truth-value: 1 if such and such and 0 if such and such.

Is this weird? It turns out that natural language, not just our semi-formal meta-language, has conditionals that seem very similar: *I fear [the consequences if we fail]*. See Lasersohn 1996 for some discussion.

H&K, of course, introduced a convention that allowed meta-language statements to be used in a place where a truth-value was expected (p.37, (9)):

> Read "$[\lambda\alpha\!: \phi.\ \gamma]$" as either (i) or (ii), whichever makes sense.
> (i) "the function which maps every α such that ϕ to γ"
> (ii) "the function which maps every α such that γ to 1, if γ, and to 0 otherwise"

Since it never makes sense to map anything to a meta-language statement, no ambiguity will ever arise.

This is the approach of von Stechow 1991.

So, one might want to extend this leeway and use it in the case of (33) as well. We could say that in general, meta-language statements supply truth-values wherever that makes sense. In that case, (33) is just shorthand for (34).

This is the approach Ede Zimmermann (pc) advocates and has been using in his classes.

Alternatively, one can introduce a new notation that indicates that a meta-language statement is being used to contribute a truth-value:

(36) $$\vdash \alpha \dashv = \begin{cases} 1 \text{ if } \alpha \\ 0 \text{ if otherwise} \end{cases}$$

Lastly, one could abandon the H&K informal meta-language approach altogether and introduce a rigidly formalized meta-language.

These lecture notes will proceed to follow H&K's approach and will not introduce any further innovations. So, (33) is illicit and only (34) is acceptable.

1.5 Supplemental Readings

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

Irene Heim & Angelika Kratzer. 1998. *Semantics in generative grammar*. Oxford: 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:

David Dowty, Robert Wall & Stanley Peters. 1981. *Introduction to Montague semantics*. Kluwer. [Chapters 5& 6].

L. T. F. Gamut. 1991. *Logic, language, and meaning*. Chicago University Press. [Volume II: Intensional Logic and Logical Grammar].

Gennaro Chierchia & Sally McConnell-Ginet. 2000. *Meaning and grammar: An introduction to semantics (2nd edition)*. MIT Press. [Chapter 5: Intensionality].

Thomas Ede Zimmermann & Wolfgang Sternefeld. 2013. *Introduction to semantics: An essential guide to the composition of meaning*. de Gruyter Mouton.

The *Stanford encyclopedia of philosophy* is always a good resource. Here's the entry on possible worlds:

Christopher Menzel. 2016. Possible worlds. In Edward N. Zalta (ed.), *The Stanford encyclopedia of philosophy*, Spring 2016. http://plato.stanford.edu/entries/possible-worlds/.

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

Saul Kripke. 1980. *Naming and necessity*. Oxford: Blackwell.

David Lewis. 1986. *On the plurality of worlds*. Oxford: Blackwell.

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

B. Jack Copeland. 2002. The genesis of possible worlds semantics. *Journal of Philosophical Logic* 31(2). 99–137. http://dx.doi.org/10.1023/A:1015273407895.

A personal history of formal semantics:

Barbara H. Partee. 2005. Reflections of a formal semanticist as of Feb 2005. ms. (longer version of introductory essay in 2004 book). http://people.umass.edu/partee/docs/BHP_Essay_Feb05.pdf.

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

Richard Montague. 1973. The proper treatment of quantification in ordinary English. In Jaako Hintikka, Julius Moravcsik & Patrick Suppes (eds.), *Approaches to natural language*, 221–242. Reprinted in Portner & Partee (2002), pp. 17–34. Dordrecht: Reidel. http://www.blackwellpublishing.com/content/BPL_Images/Content_store/Sample_chapter/9780631215417/Portner.pdf.

Barbara H. Partee & Herman L.W. Hendriks. 1997. Montague grammar. In Johan van Benthem & Alice ter Meulen (eds.), *Handbook of logic and language*, 5–91. Elsevier.

To learn more about discourse about fiction, read Lewis:

David Lewis. 1978. Truth in fiction. *American Philosophical Quarterly* 15(1). Reprinted with postscripts in D. Lewis (1983), pp. 261–280, 37–46. http://www.jstor.org/stable/20009693.

Recent reconsiderations:

Andrea Bonomi & Sandro Zucchi. 2003. A pragmatic framework for truth in fiction. *Dialectica* 57(2). Preprint http://filosofia.dipafilo.unimi.it/~bonomi/Pragmatic.pdf, 103–120. http://dx.doi.org/10.1111/j.1746-8361.2003.tb00259.x.

Richard Hanley. 2004. As good as it gets: Lewis on truth in fiction. *Australasian Journal of Philosophy* 82(1). 112–128. http://dx.doi.org/10.1080/713659790.

Inconsistencies in fictions and elsewhere are discussed in:

Achille Varzi. 1997. Inconsistency without contradiction. *Notre Dame Journal of Formal Logic* 38(4). 621–638. http://dx.doi.org/10.1305/ndjfl/1039540773.

David Lewis. 1982. Logic for equivocators. *Noûs* 16(3). Reprinted in D. Lewis (1998, pp. 97–110), 431–441. http://dx.doi.org/10.2307/2216219.

Some other interesting work on stories and pictures and their content:

Jeff Ross. 1997. *The semantics of media* (Studies in Linguistics and Philosophy (SLAP) 64). Dordrecht: Kluwer.

Sandro Zucchi. 2001. Tense in fiction. In Carlo Cecchetto, Gennaro Chierchia & Maria Teresa Guasti (eds.), *Semantic interfaces: Reference, anaphora and aspect*, 320–355. CSLI Publications. http://tinyurl.com/5ulwxwg.

Ben Blumson. 2009. Pictures, perspective and possibility. *Philosophical Studies*. http://dx.doi.org/10.1007/s11098-009-9337-2.

Astonishingly, Lewis' doctrine of the reality of the plurality of possible worlds is being paralleled (pun absolutely intended) by theoretical physicists in a number of ways. There is a controversial "many worlds" interpretation of quantum mechanics, for example. Other terms found are the "multiverse" and "parallel universes". See for starters, Kai's blog entry on a popular book on the issue, http://kaivonfintel.org/2011/01/25/many-worlds/, MIT physics professor Max Tegmark's page on the topic, http://space.mit.edu/home/tegmark/crazy.html, and a Fresh Air interview with physicist Brian Greene, who just wrote a book called *The Hidden Reality: Parallel Universes and the Deep Laws of the Cosmos*: http://www.npr.org/2011/01/24/132932268/a-physicist-explains-why-parallel-universes-may-exist.

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Chapter Two

Conditionals, First Tries

We develop a possible worlds semantics for conditionals that treats the if*-clause as an intensional operator, with a bit of context-dependency thrown in.*

2.1 The Material Implication Analysis

Consider the following example:

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

The simplest analysis of such conditional constructions is the so-called MATERIAL IMPLICATION analysis,[1] 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:

(2) $[\![\text{if}]\!] = \lambda u \in D_t.\ \lambda v \in D_t.\ u = 0 \text{ or } v = 1.$

Note that as a truth-functional connective, this *if* does not vary its denotation depending on the evaluation world. It's its arguments that vary with the evaluation world.

Applied to example in (1), 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 (1997) does a good job of persuading (or at least trying to persuade) recalcitrant logic students:

1 Quoth the Stoic philosopher Philo of Megara: "a true conditional is one which does not have a true antecedent and a false consequent" (according to Empiricus (c. 200, pp. II, 110–112)).

> 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: $H \supset C$.[2]
>
> 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:

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

If we adopt the material implication analysis, we predict that (3) 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 (3) should be true. A false prediction, if ever there was one:

2 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 (1889), a capital C standing for 'conseguenza' facing backwards. The C facing in the other (more "logical") direction was actually introduced first by Gergonne (1817), but didn't catch on.

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

Clearly, one might think that (4a) is true without at all being committed to what the material implication analysis predicts to be the equivalent statement in (4b). 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.

EXERCISE 2.1: Under the assumption that *if* has the meaning in (2), calculate the truth-conditions predicted for (5):

(5) a. No student will succeed if he goofs off.
b. No student λx (if x goofs off, x will succeed)

State the predicted truth-conditions in words and evaluate whether they correspond to the actual meaning of (5). □

2.2 The Strict Implication Analysis

If *if* is not a truth-functional connective, it seems we should treat it as an intensional operator.

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 is what the lexical entry for *if* might look like:

(6) $[\![\text{if}]\!]^{w,g} = \lambda p \in D_{\langle s,t\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w'\colon\ p(w') = 1 \rightarrow q(w') = 1.$

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

Applied to (3), we would derive the truth-conditions that (3) is true iff all of the worlds where there is a major earthquake in Cambridge tomorrow are worlds where my house collapses.

There are some obvious and immediate problems with this analysis. For one, while it's easy to imagine circumstances where the conditional (3) is judged to be true, there surely are possible worlds where there's an earthquake but my house does not collapse: perhaps, the builders in that world used all the recommended best practices to make the building earthquake-safe, perhaps it's a world where I'm simply unreasonably lucky, or the house is immediately adjacent to much sturdier neighboring buildings which keep it propped up, or Harry Potter flies by and protects the house at the last minute (he owes me a favor, after all). This problem (that the house doesn't in fact collapse in *all* possible worlds where there's an earthquake but that the conditional can still be judged true in some worlds) is accompanied with another problem: whether the conditional is true depends on what the world is like. Was the house built to exacting standards? Is it propped up by its neighbors? Does Harry Potter owe me a favor?

We can build dependence on the evaluation world in by saying that *if* only operates on worlds that are "relevant like" the evaluation world:

(7) $$[\![\text{if}]\!]^{w,g} = \lambda p \in D_{\langle s,t\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w'\colon\ p(w') = 1\ \&\ w' \text{ is relevantly like } w \rightarrow q(w') = 1.$$

Obviously, this is a semantics with a "placeholder", because what does "relevantly like" mean precisely? Now, just because the semantics is therefore rather vague and context-dependent doesn't mean it is wrong. As D. Lewis (1973) writes:

> Counterfactuals are notoriously vague. That does not mean that we cannot give a clear account of their truth conditions. It does mean that such an account must either be stated in vague terms-which does not mean ill-understood terms-or be made relative to some parameter that is fixed only within rough limits on any given occasion of language use.

In a later chapter, we will revisit the formulation in (7) and fill it out more explicitly.

EXERCISE 2.2: What prediction does the strict implication analysis in (7) make about the negated conditional in (4a)? □

Chapter Three

Modality

We turn to modal auxiliaries and related constructions. We see more context-dependency. We still quantify over possible worlds.

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 infinitive complement. So, we are dealing with the following kind of structure:

The issue of raising vs. control will probably be taken up later. If you are eager to get started on it and other questions of the morphosyntax of modals, read the handout from an LSA class Sabine and Kai taught a few years ago: http://web.mit.edu/fintel/lsa220-class-2-handout.pdf.

(1) a. Ann may be smart.
b. [Ann [λ_1 [may [t_1 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.) 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 (1b) would be the same as of (2). 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.

We will talk about reconstruction in more detail later.

(2) 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.[1] 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:

This idea goes back a long time. It was famously held by Leibniz, but there are precedents in the medieval literature, see Knuuttila (2003). See Copeland (2002) for the modern history of the possible worlds analysis of modal expressions.

(3) $[\![\text{must}]\!]^{w,g} = \lambda p_{\langle s,t\rangle}.\ \forall w'\colon\ p(w') = 1.$

(4) $[\![\text{may}]\!]^{w,g} = \lambda p_{\langle s,t\rangle}.\ \exists w'\colon\ p(w') = 1.$

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 *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:

---

1 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.

(5) You must stay.
Therefore, you may stay. VALID

(6) You may stay.
Therefore, you must stay. INVALID

(7) a. You may stay, but it is not the case that you must stay.[2]
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:

(8) You must stay, and/but also, you must leave. (leave = not stay).
CONTRADICTORY

(9) 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.

(10) a. You must stay.
b. It is not the case that you may leave.
You aren't allowed to leave.
(You may not leave.)[3]
(You can't leave.)

(11) a. You may stay.
b. It is not the case that you must leave.
You don't have to leave.
You don't need to leave.
(You needn't leave.)

---

2 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.

3 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.

Given that *stay* and *leave* are each other's negations (i.e. $[\![\text{leave}]\!]^{w,g} = [\![\text{not stay}]\!]^{w,g}$, and $[\![\text{stay}]\!]^{w,g} = [\![\text{not leave}]\!]^{w,g}$), the LF-structures of these equivalent pairs of sentences can be seen to instantiate the following schemata:[4]

(12) a. $\textit{must}\ \phi \equiv \textit{not}\ [\textit{may}\ [\textit{not}\ \phi]]$
b. $\textit{must}\ [\textit{not}\ \psi] \equiv \textit{not}\ [\textit{may}\ \psi]$

(13) a. $\textit{may}\ \phi \equiv \textit{not}\ [\textit{must}\ [\textit{not}\ \phi]]$
b. $\textit{may}\ [\textit{not}\ \psi] \equiv \textit{not}\ [\textit{must}\ \psi]$

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.

More linguistic data regarding the "parallel logic" of modals and quantifiers can be found in Larry Horn's dissertation (Horn 1972).

(14) a. $\forall x \phi \equiv \neg \exists \neg \phi$
b. $\forall x \neg \phi \equiv \neg \exists x \phi$

(15) 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

(16) $[\![\text{may}]\!]^{w,g} = \lambda p_{\langle s,t \rangle}.\ \exists w' \colon\ p(w') = 1.$

4 In logicians' jargon, *must* and *may* behave as DUALS of each other. For definitions of "dual", see Barwise & Cooper (1981, p. 197) or Gamut (1991, vol.2,238).

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.

(17) $[\![\text{may}]\!]^{w,g} = \lambda p.\ \exists w'$ compatible with the evidence in w: $p(w') = 1$.[5]

(18) $[\![\text{must}]\!]^{w,g} = \lambda p.\ \forall w'$ compatible with the evidence in w: $p(w') = 1$.

Let us consider a different example:

(19) 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:

(20) $[\![\text{have-to}]\!]^{w,g} = \lambda p.\ \forall w'$ 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 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

5 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.

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 MODALITY.) Here are some initial illustrations.

(21) EPISTEMIC MODALITY

A: Where is John?
B: I don't know. He *may* be at home.

(22) DEONTIC MODALITY

A: Am I allowed to stay over at Janet's house?
B: No, but you *may* bring her here for dinner.

(23) 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 available evidence. 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 (23) 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.)

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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 (1977, 1978, 1981, 1991).

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?

It is well-known that natural language quantification is in general subject to contextual restriction. See Stanley & Szabó (2000) for a recent discussion.

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 subcategorizing for a kind of invisible pronoun, a free variable that stands for a set of possible worlds. So we posit LF-structures like this:

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

$p_{\langle n,\langle s,t\rangle\rangle}$ 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 $\langle st,t\rangle$.

We are using the notation for variables of types other than e, introduced by Heim & Kratzer. See p. 213. An index on a variable now is an ordered pair of a natural number and a type.

Q: Can you think of overt anaphoric expressions that are arguably of the type $\langle s,t\rangle$, a proposition?

(25) a. $[\![\text{must}]\!]^{w,g} = [\![\text{have-to}]\!]^{w,g} = [\![\text{need-to}]\!]^{w,g} = \ldots =$
$\lambda p \in D_{\langle s,t\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w \in W\ [p(w) = 1 \rightarrow q(w) = 1]$ in set talk: $p \subseteq q$

b. $[\![\text{may}]\!]^{w,g} = [\![\text{can}]\!]^{w,g} = [\![\text{be-allowed-to}]\!]^{w,g} = \ldots =$
$\lambda p \in D_{\langle s,t\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \exists w \in W\ [p(w) = 1\ \&\ q(w) = 1]$ in set talk: $p \cap q \neq \emptyset$

On this approach, the epistemic, deontic, etc. "readings" of individual occurrences 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

(26) 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 some 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:

Quoted from Kratzer (1991). In Kratzer (1981), the hydrangeas were *Zwetschgenbäume* 'plum trees'. The German word *Zwetschge*, by the way, is etymologically derived from the name of the city Damascus (Syria), the center of the ancient plum trade.

> Consider sentences (27) and (28):
>
> (27) Hydrangeas can grow here.
>
> (28) 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 (27). In such a situation, the proposition expressed by (27) 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 (28) would express a false proposition. What counts here is the complete evidence available. And this evidence is not compatible with the existence of hydrangeas.
>
> (27) together with our scenario illustrates the pure CIRCUMSTANTIAL reading of the modal *can*. [...]. (28) 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:

(29) 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 $\{w'$: the house rules that are in force in w 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 $\langle s, st\rangle$.

(30) $[_{I'}\ [_{I}$ must $R_{\langle n,\langle s,st\rangle\rangle}$ $]\ [_{VP}$ you quiet$]]$

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

(31) a. $[\![\text{must}]\!]^{w,g} = [\![\text{have-to}]\!]^{w,g} = [\![\text{need-to}]\!]^{w,g} = \ldots =$

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

$\lambda R \in D_{\langle s,st\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w' \in W\ [R(w)(w') = 1 \rightarrow q(w') = 1]$

b. $[\![\text{may}]\!]^{w,g} = [\![\text{can}]\!]^{w,g} = [\![\text{be-allowed-to}]\!]^{w,g} = \ldots =$

in set talk: $(R(w) \cap q \neq \emptyset$

$\lambda R \in D_{\langle s,st\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \exists w' \in W\ [R(w)(w') = 1\ \&\ q(w') = 1]$

Let us see now how this solves the contingency problem.

(32) Let w be a world, and assume that the context supplies an assignment g such that $g(R_{\langle 17,\langle s,st\rangle\rangle}) = \lambda w.\ \lambda w'.$ the house rules in force in w are obeyed in w'

$[\![\text{must } R_{\langle 17,\langle s,st\rangle\rangle} \text{ you quiet}]\!]^{w,g} =$ (IFA)

$[\![\text{must } R_{\langle 17,\langle s,st\rangle\rangle}]\!]^{w,g}(\lambda w'\ [\![\text{you quiet}]\!]^{w'}) =$ (FA)

$[\![\text{must}]\!]^{w,g}\ ([\![R_{\langle 17,\langle s,st\rangle\rangle}]\!]^{w,g})\ (\lambda w'\ [\![\text{you quiet}]\!]^{w'}) =$ (lex. entries *you*, *quiet*)

$[\![\text{must}]\!]^{w,g}\ ([\![R_{\langle 17,\langle s,st\rangle\rangle}]\!]^{w,g})\ (\lambda w'.$ you are quiet in $w') =$ (lex. entry *must*)

$\forall w' \in W : [\![R_{\langle 17,\langle s,st\rangle\rangle}]\!]^{w,g}(w)(w') = 1 \rightarrow$ you are quiet in $w' =$ (pronoun rule)

$\forall w' \in W : g(R_{\langle 17,\langle s,st\rangle\rangle})(w)(w') = 1 \rightarrow$ you are quiet in $w' =$ (def. of g)

$\forall w' \in W$ [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 (32), the truth-value of (30) depends on the evaluation world w.

EXERCISE 3.2: Describe two worlds w_1 and w_2 so that
$[\![\text{must } R_{\langle 17,\langle s,st\rangle\rangle} \text{ you quiet}]\!]^{w_1,g} = 1$ and $[\![\text{must } R_{\langle 17,\langle s,st\rangle\rangle} \text{ you quiet}]\!]^{w_2,g} = 0$. □

Exercise 3.3: In analogy to the deontic relation $g(R_{\langle 17,\langle s,st\rangle\rangle})$ defined in (32), define an appropriate relation that yields an epistemic reading for a sentence like *You may be quiet.* □

3.2.4 Iteration

Consider the following example:

(33) 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''.

There is more to be said about which modals can embed under which other modals. See for some discussion the handout mentioned earlier: http://web.mit.edu/fintel/lsa220-class-2-handout.pdf.

Assume the following LF:

(34) $[_{I'}$ [might $R_{\langle 1,\langle s,st\rangle\rangle}$] $[_{VP}$ [have-to $R_{\langle 2,\langle s,st\rangle\rangle}$] $[_{IP}$ 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.

From now on, we will omit the type-designation of variables whenever we feel confident that their type is easy to figure out from the context.

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:

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

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

(37) John *can* run a mile in 5 minutes.

(38) This *has* to be the White House.

(39) 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 $\langle\langle s, st\rangle, \langle st, t\rangle\rangle$:

(40) (repeated from earlier):
For any $w \in W$: $[\![\text{must}]\!]^{w,g}$
$\lambda R \in D_{\langle s,st\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w' \in W\ [R(w)(w') = 1 \rightarrow q(w') = 1]$
(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:

(41) (repeated from even earlier):
$[\![\text{must}]\!]^{w,g} = \lambda p \in D_{\langle s,t\rangle}.\ \lambda q \in D_{\langle s,t\rangle}.\ \forall w \in W\ [p(w) = 1 \rightarrow q(w) = 1]$
(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:

(42) $[_{I'}\ [_{I}$ must $[\ R_{\langle 4,\langle s,st\rangle\rangle}\ w^*]]\ [_{VP}$ 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:

Note that as soon as we're introducing an object language expression whose extension is a possible world, we will now have expressions of type s and should also introduce the domain of things of type s: $D_s = W$.

(43) For any $w \in W : [\![w*]\!]^{w,g} = w$.[6]

6 D. R. Dowty (1982) introduced an analogous symbol to pick out the evaluation *time*. We have chosen the star-notation to allude to this precedent.

When $\mathsf{R}_{\langle 4,\langle s,st\rangle\rangle}$ 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:

(44) For any $w \in W$ and any assignment g:
$[\![\mathsf{R}_{\langle 4,\langle s,st\rangle\rangle}(\mathrm{w}^*)]\!]^{w,g} = \mathrm{g}(\langle 4, \langle s, st\rangle\rangle)(w)$.

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 (42) 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. Nevertheless, make sure you understand what we just proposed, since it may turn out to be useful.

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 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:

(45) (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 (45). It will be the following:

(46) $\lambda w.\ \lambda p.$ 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:

(47) 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 uses the term MODAL BASE for the conversational background that determines the set of accessible worlds. 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 (47)) is reflexive. □

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

EXERCISE 3.8: The definition in (47) 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 $D_{\langle s,st\rangle}$.[7]

- 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 (47) 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:

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

  (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 (47) will be one-to-one. □

3.4 Supplementary Readings

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

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7 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 (47) 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 (48) of the second part of the exercise. It is defined as follows:

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

Angelika Kratzer. 1981. The notional category of modality. In Hans-Jürgen Eikmeyer & Hannes Rieser (eds.), *Words, worlds, and contexts: New approaches in word semantics* (Research in Text Theory 6), 38–74. Berlin: de Gruyter.

Angelika Kratzer. 1991. Modality. In Arnim von Stechow & Dieter Wunderlich (eds.), *Semantics: An international handbook of contemporary research*, 639–650. Berlin: de Gruyter. https://udrive.oit.umass.edu/kratzer/kratzer-modality.pdf.

Kratzer has been updating her classic papers for a volume of her collected work on modality and conditionals. These are very much worth studying: http://semanticsarchive.net/Archive/Tc2NjA1M/.

A major new resource on modality is Paul Portner's book:

Paul Portner. 2009. *Modality*. Oxford University Press.

You might also profit from other survey-ish type papers:

Kai von Fintel. 2005. Modality and language. In Donald M. Borchert (ed.), *Encyclopedia of philosophy – second edition*. MacMillan. http://mit.edu/fintel/fintel-2005-modality.pdf.

Kai von Fintel & Anthony S. Gillies. 2007. An opinionated guide to epistemic modality. In Tamar Szabó Gendler & John Hawthorne (eds.), *Oxford studies in epistemology: Volume 2*, 32–62. Oxford University Press. http://mit.edu/fintel/fintel-gillies-2007-ose2.pdf.

Eric Swanson. 2008. Modality in language. *Philosophy Compass* 3(6). 1193–1207. http://dx.doi.org/10.1111/j.1747-9991.2008.00177.x.

Valentine Hacquard. 2009. Modality. ms, prepared for *Semantics: An international handbook of meaning*, edited by Klaus von Heusinger, Claudia Maienborn, and Paul Portner. http://ling.umd.edu/~hacquard/papers/HoS_Modality_Hacquard.pdf.

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.

Rajesh Bhatt. 1997. Obligation and possession. In Heidi Harley (ed.), *Papers from the upenn/mit roundtable on argument structure and aspect*, vol. 32 (MIT Working Papers in Linguistics), 21–40. http://people.umass.edu/bhatt/papers/bhatt-haveto.pdf.

Susi Wurmbrand. 1999. Modal verbs must be raising verbs. *West Coast Conference on Formal Linguistics (WCCFL)* 18. 599–612. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.35.7442&rep=rep1&type=pdf.

Annabel Cormack & Neil Smith. 2002. Modals and negation in English. In Sjef Barbiers, Frits Beukema & Wim van der Wurff (eds.), *Modality and its interaction with the verbal system*, 133–163. Benjamins.

Jonny Butler. 2003. A minimalist treatment of modality. *Lingua* 113(10). 967–996. http://dx.doi.org/10.1016/S0024-3841(02)00146-8.

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

Kai von Fintel & Sabine Iatridou. 2003. Epistemic containment. *Linguistic Inquiry* 34(2). 173–198. http://dx.doi.org/10.1162/002438903321663370.

Valentine Hacquard's MIT dissertation is a rich source of cross-linguistic issues in modality, as is Fabrice Nauze's Amsterdam dissertation:

Valentine Hacquard. 2006. *Aspects of modality*. Massachusetts Institute of Technology PhD thesis. http://people.umass.edu/hacquard/hacquard_thesis.pdf.

Fabrice Nauze. 2008. *Modality in typological perspective*. Universiteit van Amsterdam PhD thesis. http://www.illc.uva.nl/Publications/Dissertations/DS-2008-08.text.pdf.

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

Ian Hacking. 1967. Possibility. *The Philosophical Review* 76(2). 143–168. http://dx.doi.org/10.2307/2183640. http://www.jstor.org/stable/2183640.

Paul Teller. 1972. Epistemic possibility. *Philosophia* 2(4). 302–320. http://dx.doi.org/10.1007/BF02381591.

Keith DeRose. 1991. Epistemic possibilities. *The Philosophical Review* 100(4). 581–605. http://dx.doi.org/10.2307/2185175.

Andy Egan, John Hawthorne & Brian Weatherson. 2005. Epistemic modals in context. In Gerhard Preyer & Georg Peter (eds.), *Contextualism in philosophy: Knowledge, meaning, and truth*, 131–170. Oxford: Oxford University Press.

Andy Egan. 2007. Epistemic modals, relativism, and assertion. *Philosophical Studies* 133(1). 1–22. http://dx.doi.org/10.1007/s11098-006-9003-x.

John MacFarlane. 2006. Epistemic modals are assessment-sensitive. ms, University of California, Berkeley, forthcoming in an OUP volume on epistemic modals, edited by Brian Weatherson and Andy Egan. http://sophos.berkeley.edu/macfarlane/epistmod.pdf.

Tamina Stephenson. 2007. Judge dependence, epistemic modals, and predicates of personal taste. *Linguistics and Philosophy* 30(4). 487–525. http://dx.doi.org/10.1007/s10988-008-9023-4.

John Hawthorne. 2007. Eavesdroppers and epistemic modals. ms, Rutgers University, to appear in the proceedings of the 2007 Sofia Conference in Mexico, in a supplement to *Noûs*.

Kai von Fintel & Anthony S. Gillies. 2008a. CIA leaks. *The Philosophical Review* 117(1). 77–98. http://dx.doi.org/10.1215/00318108-2007-025.

Kai von Fintel & Anthony S. Gillies. 2008b. *Might* made right. To appear in a volume on epistemic modality, edited by Andy Egan and Brian Weatherson, Oxford University Press. http://mit.edu/fintel/fintel-gillies-2008-mmr.pdf.

A recent SALT paper by Pranav Anand and Valentine Hacquard tackles what happens to epistemic modals under attitude predicates:

Pranav Anand & Valentine Hacquard. 2008. Epistemics with attitude. *Semantics and Linguistic Theory (SALT)* 18. http://dx.doi.org/1813/13025.

Evidentiality is a topic closely related to epistemic modality. Some references:

Thomas Willett. 1988. A cross-linguistic survey of the grammaticalization of evidentiality. *Studies in Language* 12(1). 51–97.

Alexandra Y. Aikhenvald. 2004. *Evidentiality*. Oxford: Oxford University Press.

Hans Bernhard Drubig. 2001. On the syntactic form of epistemic modality. ms, Universität Tübingen. http://www.sfb441.uni-tuebingen.de/b2/papers/DrubigModality.pdf.

Eleanor M. Blain & Rose-Marie Déchaine. 2007. Evidential types: Evidence from Cree dialects. *International Journal of American Linguistics* 73(3). 257–291. http://dx.doi.org/10.1086/521728.

Eric McCready & Norry Ogata. 2007. Evidentiality, modality and probability. *Linguistics and Philosophy* 30(2). 147–206. http://dx.doi.org/10.1007/s10988-007-9017-7.

Peggy Speas. 2008. On the syntax and semantics of evidentials. *Language and Linguistics Compass* 2(5). 940–965. http://dx.doi.org/10.1111/j.1749-818X.2008.00069.x.

Kai von Fintel & Anthony S. Gillies. 2010. *Must* ... stay ... strong! *Natural Language Semantics* 18(4). 351–383. http://dx.doi.org/10.1007/s11050-010-9058-2.

Modals interact with disjunction and indefinites to generate so-called FREE CHOICE-readings, which are a perennial puzzle. Here is just a very small set of initial references:

Hans Kamp. 1973. Free choice permission. *Proceedings of the Aristotelian Society, New Series* 74. 57–74. http://www.jstor.org/stable/4544849.

Thomas Ede Zimmermann. 2000. Free choice disjunction and epistemic possibility. *Natural Language Semantics* 8(4). 255–290. http://dx.doi.org/10.1023/A:1011255819284.

Katrin Schulz. 2005. A pragmatic solution for the paradox of free choice permission. *Synthese* 147(2). 343–377. http://dx.doi.org/10.1007/s11229-005-1353-y.

Maria Aloni. 2007. Free choice, modals, and imperatives. *Natural Language Semantics* 15(1). 65–94. http://dx.doi.org/10.1007/s11050-007-9010-2.

Luis Alonso-Ovalle. 2006. *Disjunction in alternative semantics*. University of Massachusetts at Amherst PhD thesis. http://alonso-ovalle.net/index.php?page_id=28.

Danny Fox. 2007. Free choice and the theory of scalar implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presupposition and implicature in compositional semantics*, 537–586. New York: Palgrave Macmillan. http://web.mit.edu/linguistics/people/faculty/fox/free_choice.pdf.

Robert van Rooij. 2006. Free choice counterfactual donkeys. *Journal of Semantics* 23(4). 383–402. http://dx.doi.org/10.1093/jos/ffl004.

Chapter Four

Conditionals: The Restrictor Theory

We look at the interaction of conditionals with modals and find that we need a better theory of if*-clauses.*

We now have a basic theory of conditionals in place as well as a basic theory of modals. Both are treated as intensional operators that move us from the initial evaluation world to another set of worlds: in the case of conditionals, those worlds where the antecedent is true that are otherwise relevantly like the evaluation world; in the case of modals, to whatever worlds the contextually supplied accessibility relation assigns to the evaluation world.

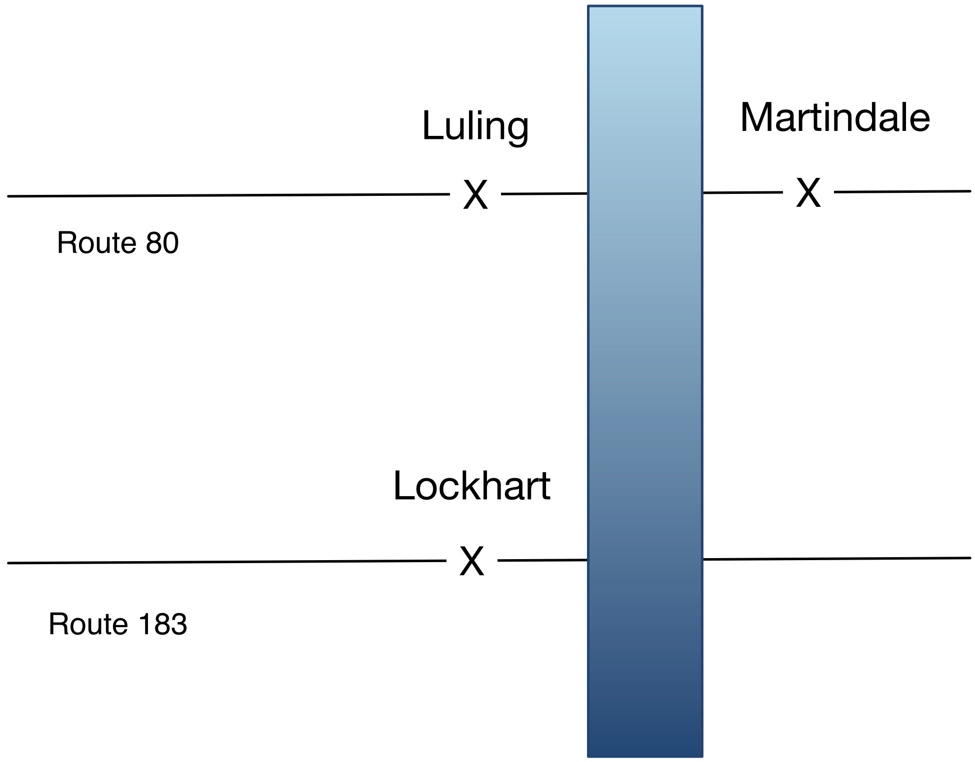
4.1 The interaction of conditionals and modals

This means that if a sentence contains both a conditional and a modal, we expect them to work together to express nested intensional shifting, very much like our analysis of the sentence *you might have to leave* in the previous chapter.

Consider then the following sentence:

(1) If we are on Route 183, we must be in Lockhart.

Imagine two friends on a road trip. They have lost all their electronic devices that might have had GPS functionality. They are lost, except that they have an old-fashioned map with them. Here's a schematic representation of the relevant geographical area:



Our friends are lost. They might be on Route 80 or they might be on Route 183. They come to a river. They do not know which direction they're facing (it's high noon in Texas). They determine that they are in one of three towns: Lockhart, Luling, or Martindale. One of them says (1). That seems true.

Let's consider what our semantics predicts.

EXERCISE 4.1: Calculate the truth-conditions of (1) with respect to an arbitrary world w, and assignment function g. Assume that *must* scopes over *we be in Lockhart*. Do not worry about the internal composition of the two embedded clauses.

Assume the following lexical entries for *if* and *must*:

$[\![\text{if}]\!]^{w,g} = \lambda p_{st}.\lambda q_{st}.\ \forall w'$: $p(w') = 1$ & w' relevantly like $w \rightarrow q(w') = 1$

$[\![\text{must}]\!]^{w,g} = \lambda p_{st}.\ \forall w'$ compatible with the evidence in w: $p(w') = 1$ $\square$

The prediction is that the conditional takes us to worlds where our friends are on Route 183 and that are otherwise like the evaluation world. The modal then looks at the evidence in those Route 183 worlds and says that in all worlds compatible with that evidence, they are in Lockhart.

This is wrong: no matter whether they are on Route 183 or on Route 80, our friends are lost. So, their evidence in any of the relevant worlds is the same: inconclusive as to where they are. In none of the worlds do they have evidence about which of the three possible towns they are in. Thus, our semantics incorrectly predicts that (1) is false in the given scenario. But it is clearly true.

4.2 *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. D. Lewis 1975, p. 11

Building on Lewis' insight, 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. (Kratzer 1986)

Let us repeat this:

(2) 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 (1). 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 Route 80, they might be in Lockhart. In all, we have a good analysis of what (1) means.

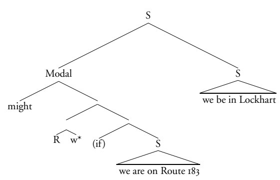


Figure 4.1: LF for (1)

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 the LF in the margin. 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 4.2: 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*.

Finally, we could rethink the LF and treat the *if*-clause as a direct sister of the modal. Devise a meaning for *if* that would give the right meaning for (1).□

What about cases like the earthquake conditional from Chapter 2, now?

(3) If there's an earthquake, my house will collapse.

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.

Supplementary Readings

A short handbook article on conditionals:

Kai von Fintel. 2009. Conditionals. ms, prepared for *Semantics: An international handbook of meaning*, edited by Klaus von Heusinger, Claudia Maienborn, and Paul Portner. http://mit.edu/fintel/fintel-2009-hsk-conditionals.pdf.

Overviews of the philosophical work on conditionals:

Dorothy Edgington. 1995. On conditionals. *Mind* 104(414). 235–329. 10.1093/mind/104.414.235.

Jonathan Bennett. 2003. *A philosophical guide to conditionals*. Oxford University Press.

A handbook article on the logic of conditionals:

Donald Nute. 1984. Conditional logic. In Dov Gabbay & Franz Guenthner (eds.), *Handbook of philosophical logic. volume ii*, 387–439. Dordrecht: Reidel.

Three indispensable classics:

David Lewis. 1973. *Counterfactuals*. Oxford: Blackwell.

Robert Stalnaker. 1968. A theory of conditionals. In Nicholas Rescher (ed.), *Studies in logical theory* (American Philosophical Quarterly Monograph Series 2), 98–112. Oxford: Blackwell.

Robert Stalnaker. 1975. Indicative conditionals. *Philosophia* 5(3). 269–286. http://dx.doi.org/10.1007/BF02379021.

The Restrictor Analysis:

David Lewis. 1975. Adverbs of quantification. In Edward Keenan (ed.), *Formal semantics of natural language*, 3–15. Cambridge University Press.

Angelika Kratzer. 1986. Conditionals. *Chicago Linguistics Society* 22(2). 1–15. https://udrive.oit.umass.edu/kratzer/kratzer-conditionals.pdf.

The application of the restrictor analysis to the interaction of nominal quantifiers and conditionals:

Kai von Fintel. 1998. Quantifiers and 'if'-clauses. *The Philosophical Quarterly* 48(191). 209–214. http://dx.doi.org/10.1111/1467-9213.00095. http://mit.edu/fintel/www/qandif.pdf.

Kai von Fintel & Sabine Iatridou. 2002. If and when *If*-clauses can restrict quantifiers. ms, MIT. http://mit.edu/fintel/fintel-iatridou-2002-ifwhen.pdf.

James Higginbotham. 2003. Conditionals and compositionality. *Philosophical Perspectives* 17(1). 181–194. http://dx.doi.org/10.1111/j.1520-8583.2003.00008.x.

Sarah-Jane Leslie. 2009. *If*, *unless*, and quantification. In Robert J. Stainton & Christopher Viger (eds.), *Compositionality, context and semantic values: Essays in honour of Ernie Lepore*, 3–30. Springer. http://dx.doi.org/10.1007/978-1-4020-8310-5_1.

Janneke Huitink. 2009b. Quantified conditionals and compositionality. ms, to appear in *Language and Linguistics Compass*. http://user.uni-frankfurt.de/~huitink/compass-conditionals-final.pdf.

Syntax of conditionals:

Kai von Fintel. 1994. *Restrictions on quantifier domains*. Amherst, MA: University of Massachusetts PhD thesis. http://semanticsarchive.net/Archive/jA3N2IwN/fintel-1994-thesis.pdf, Chapter 3: "Conditional Restrictors"

Sabine Iatridou. 1993. On the contribution of conditional *Then*. *Natural Language Semantics* 2(3). 171–199. http://dx.doi.org/10.1007/BF01256742.

Rajesh Bhatt & Roumyana Pancheva. 2006. Conditionals. In *The Blackwell companion to syntax*, vol. 1, 638–687. Blackwell. http://www-rcf.usc.edu/~pancheva/bhatt-pancheva_syncom.pdf.

A shifty alternative to the restrictor analysis:

Anthony S. Gillies. 2009. On truth-conditions for *if* (but not quite only *if*). *The Philosophical Review* 118(3). 325–349. http://dx.doi.org/10.1215/00318108-2009-002.

Anthony S. Gillies. 2010. Iffiness. *Semantics and Pragmatics* 3(4). 1–42. http://dx.doi.org/10.3765/sp.3.4.

The Belnap alternative:

Jr. Belnap Nuel D. 1970. Conditional assertion and restricted quantification. *Noûs* 4(1). 1–12. http://dx.doi.org/10.2307/2214285.

Jr. Belnap Nuel D. 1973. Restricted quantification and conditional assertion. In Hugues Leblanc (ed.), *Truth, syntax and modality: Proceedings of the Temple University conference on alternative semantics*, vol. 68 (Studies in Logic and the Foundations of Mathematics), 48–75. Amsterdam: North-Holland.

Kai von Fintel. 2007. *If*: The biggest little word. Slides from a plenary address given at the Georgetown University Roundtable, March 8, 2007. http://mit.edu/fintel/gurt-slides.pdf.

Janneke Huitink. 2008. *Modals, conditionals and compositionality*. Radboud Universiteit Nijmegen PhD thesis. http://user.uni-frankfurt.de/~huitink/Huitink-dissertation.pdf, Chapters 1 and 2 give a nice summary of what we're covering in this class, while Chapter 5 is about the Belnap-method.

Janneke Huitink. 2009a. Domain restriction by conditional connectives. ms, Goethe-University Frankfurt. http://semanticsarchive.net/Archive/zg2MDM4M/Huitink-domainrestriction.pdf.

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Chapter Five

DPs and Scope in Modal Contexts

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

5.1 *Specific* vs. *Non-specific* as a Scope Ambiguity

Consider a sentence with a modal and a quantified noun phrase:

(1) We must invite a friend of Abigail's.

The sentence appears ambiguous. One reading is that there is a specific friend of Abigail's who we must invite. The other reading is that we are required to invite some friend of Abigail's or other, doesn't matter which one. The latter is a "non-specific" reading.

Our semantics will deliver both readings as long as we allow two landing sites for QR of *a friend of Abigail's.*

Exercise 5.1: Compute the truth-conditions for two possible LFs for (1):

(2) a. [must (a friend of Abigail's λx_e. we invite x)]
b. [a friend of Abigail's λx_e. (must (we invite x))] □

5.2 Raised subjects

We will now look at cases in which a DP that is superficially *higher* than a modal operator can still be read non-specific. In these cases, it is the specific reading which we obtain if the LF looks essentially like the surface structure, and the non-specific reading for which we apparently have to posit a non-trivial covert derivation.

5.2.1 Examples of non-specific 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:

(3) 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 (3) has the following S-structure, which is also an interpretable LF.

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

What does (4) 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_0 be the utterance world. Then the truth-condtion calculated by our rules is as follows.

(5) $\exists x[x$ is a person in w_0 &
$\forall w'[w'$ is compatible with what I believe in $w_0 \rightarrow$ x was here in $w']]$

But this is not the intended meaning. For (5) 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 (3). 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 (3). What you did understand me to be claiming, apparently, was not (5) but (6).

(6) $\forall w'[w'$ is compatible with what I believe in w_0
$\rightarrow \exists x$ [x is a person in w' & x was here in w']]

In other words – to use the terminology we introduced in the last section – the DP *somebody* in (3) appears to have a non-specific reading.

How can sentence (3) have the meaning in (6)? The LF in (4), as we saw, means something else; it expresses a specific reading, which typically is false when (3) 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 (3), i.e., the structure *before* the subject has raised:

(7) [IP e [I′ [must R] [somebody have-been-here]]]

(7) means precisely (6) (assuming that the unfilled Spec-of-IP position is semantically vacuous), as you can verify by calculating its interpretation by our rules. So is (7) (one of) the LF(s) for (3), and what assumption about syntax allow it to be generated? Or are there other – perhaps less obvious, but easier to generate – candidates for the non-specific LF-structure of (3)?

Before we get into these question, let's look at a few more examples. Each of the following sentences, we claim, has a non-specific 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.

(8) Everyone in the class may have received an A.
$\exists w'[w'$ conforms to what I believe in w &
$\forall x$[x is in this class in w' $\rightarrow$ x received an A in w']].

(9) At least two semanticists have to be invited.
$\forall w'[w'$ conforms to what is desirable in w
$\rightarrow \exists_2 x$ [x is a semanticist in w' & x is invited in w']].

(10) Somebody from New York is expected to win the lottery.
$\forall w'[w'$ conforms to what is expected in w
$\rightarrow \exists x$[x is a person from NY in w' & x wins the lottery in w']]

(11) Somebody from New York is likely to win the lottery.
$\forall w'[w'$ is as likely as any other world, given I know in w
$\rightarrow \exists x$[x is a person from NY in w' & x wins the lottery in w']][1]

1 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,

(12) One of these two people is probably infected.
$\forall w'[w'$ is as likely as any other world, given what I know in w
$\rightarrow \exists x[x$ is one of these two people & x is in infected in $w']]$

To bring out the intended non-specific 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, (12) appears to be true. It would not be true under a specific reading, because neither one of the two people is infected in every one of the likely worlds.

A word of clarification about our empirical claim: We have been concentrating on the observation that non-specific readings are *available*, but have not addressed the question whether they are the *only* available readings or coexist with equally possible specific readings. Indeed, some of the sentences in our list appear to be ambiguous: For example, it seems that (10) could also be understood to claim that there is a particular New Yorker who is likely to win (e.g., because he has

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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 a 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.

bribed everybody). Others arguably are not ambiguous and can only be read non-specific. This is what von Fintel & Iatridou (2003) claim about sentences like (8). They note that if (8) also allowed a specific reading, it should be possible to make coherent sense of (13).

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

In fact, (13) sounds contradictory, which they show is explained if only the non-specific 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 non-specific readings, and also for the absence, in at least some of our examples, of specific 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 specific readings where they are missing.

To complicate the empirical picture further, there are also examples where raised subjects are unambiguously specific. Such cases have been around in the syntactic literature for a while, and they have 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.

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

(14) does not have a non-specific reading parallel to the one for (11) 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 specific and non-specific 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.

5.2.2 Syntactic "Reconstruction"

Given that the non-specific reading of (3) we are aiming to generate is equivalent to the formula in (6), 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 defended in Sauerland & Elbourne (2002), 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 (1993). 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 than 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 non-specific 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 (1977): 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.

(15) t_j λ_i [must-R [someone λ_j [t_i 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 (15) interpretable, at least not within our framework of assumptions, for (16) is still not a candidate for an actual reading of (3).

(16) 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 non-specific 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 non-specific 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 non-specific 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.[2]

5.2.3 Some Alternatives to Syntactic Reconstruction

Besides (some version of) syntactic reconstruction, there are many other ways in which one try to generate non-specific 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 non-specific 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.

1. Raising the modal operator, variant 1: no trace Conceivably, an LF for the non-specific reading of (3) might be derived from the S-structure (=(4)) 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 (4). So this would not be a way to provide an LF for the non-specific

2 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.

reading. If there was no trace left however (and also no binder index introduced), we indeed would obtain the non-specific reading.

EXERCISE 5.2: 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? □

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 non-specific reading we have assumed so far. Rather, it is a "narrow-Q, R-de-re" interpretation in the sense discussed in the next chapter.]

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. (4), gives us the specific 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 (4) 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 $\langle et, t\rangle$:

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

(17) is interpretable in our system, but again, as above, the predicted interpretation is not exactly the non-specific reading as we have been describing it so far, but a "narrow-Q, R-de-re" reading.

EXERCISE 5.3: 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. (18) contains a universal quantifier and a negation, and it is scopally ambiguous between the readings in (a) and (b).

(18) 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 (18) by generating an LF (e.g. by some version of syntactic reconstruction") 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.) □

Exercise 5.4: 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 (4) interpretable. (At least not if we stick exactly to our current composition rules.) □

4. Higher type for trace of raising, variant 2: type $\langle s,\langle et,t\rangle\rangle$ If we want to get *exactly* the non-specific reading that results from syntactic reconstruction out of a surface-like LF of the form (4), 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 connot combine by either FA or IFA, but it works if we employ another variant of functional application.[3]

(19) *Extensionalizing Functional Application* (EFA)
If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, then, for any world w and assignment g:
if $[\![\beta]\!]^{w,g}(w)$ is a function whose domain contains $[\![\gamma]\!]^{w,g}$,
then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}(w)([\![\gamma]\!]^{w,g})$.

Exercise 5.5: Calculate the truth-conditions of (4) under the assumption that the trace of the subject quantifier is of type $\langle s,\langle\langle e,t\rangle,t\rangle\rangle$. □

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

3 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 $[\![\beta]\!]^{w}$ to $[\![\gamma]\!]^{w}$; IFA applies $[\![\beta]\!]^{w}$ to $\lambda w'.[\![\gamma]\!]^{w'}$; and EFA applies $[\![\beta]\!]^{w}(w)$ to $[\![\gamma]\!]^{w}$. At most one of them will be applicable to each given branching node, depending on the type of $[\![\gamma]\!]^{w}$.

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

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" non-specific 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.

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

If I say this instead of our original (3) 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 (20), however, that if Bill isn't a neat-freak, then it wasn't him in my office. I.e., (20) *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 (20) expresses the "genuine" non-specific reading in (21), but not if it expresses the "hybrid" reading in (22).

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

(22) $\forall w'[w'$ is compatible with what I believe in $w_0 \rightarrow$
$\exists x[x$ is a neatfreak *in* w_0 and x 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 (21).

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.

(23) 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 synatctic 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):

(24) a. A student of his_1 seems to David_1 to be at the party.
^{OK}specific, ^{OK}non-specific
b. A student of David's_1 seems to him_1 to be at the party.
^{OK}specific, *non-specific

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

Raising of idiom chunks

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

(26) ?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 non-specific readings for raised subjects.

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