Lecture Notes on Intensional Semantics

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A note about the lecture notes:

The notes for this course have been evolving for years now, starting with some old notes from the early 1990s by Angelika Kratzer, Irene Heim, and myself, which have since been modified and expanded every year by Irene or myself. Because this version of the notes have not been seen by my co-authors, I alone am responsible for any defects. Because of a recent reorganization of the material, there are quite likely to be numerous errors. I hope they're not too misleading.

– Kai von Fintel, July 2002

1 First Steps into Intensionality

Charles Hockett (1960, 1968) in a famous article (and a follow-up) presented a list of "design features of human language". This list continues to play a role in current discussions of animal communication. One of the design features is "displacement". Human language is not restricted to discourse about the *actual here and now*. Here are some examples of displacement.

Spatial Displacement:

(1)   In Hamburg, it is raining right now.

Temporal Displacement:

(2)   A few days ago, it rained.

Modal Displacement:

(3)   If the low pressure system had not moved away, it might have been raining now.

Our concern will be to account for displacement in our formal system. We will see in a moment that we currently cannot do so. We will start with a unit on temporal matters. Then, we turn to modality.

1.1   "Former" Again

[This recapitulates the brief discussion on p. 72 of H&K.]

(4)   John is a former teacher.

Can we write a lexical entry for *former*? What would have to be its type?

Can ⟦*former*⟧ be of type <e,t>? There are two problematic predictions. First, *former* should be able to be used predicatively:

(5)   *John is former.

Secondly, ⟦*former*⟧ would have to combine with the set denoted by *teacher* via the composition principle of Predicate Modification (PM). But then, the sentence in (4) should entail that John is a teacher.

Both predictions are wrong. Contrast in this respect *former* with adjectives like *female* where both predictions are correct.

Could ⟦*former*⟧ be of type <et,et>? This would not anymore have the two problems just identified with the lower type <e,t>. But there is another fatal problem. If two predicates have the same extension, then applying *former* to either predicate should give the same result. This is not good. Assume that it so happens that all and only the teachers are Republicans. Then, we incorrectly predict that all former teachers are former Republicans. But we can easily imagine that our situation (where all current teachers are Republicans) is one in which every former teacher is also a Republican

1.2   The Solution: Intensional Semantics

Without even considering specific proposals for what the meaning of *former* might be, we have shown that it cannot be of either of the types we have previously employed for adjectives. What can we do?

Well, let us just think about the intuitive meaning of *former teacher*. While there are a bunch of people that are currently teachers there are others that are not now teachers but were at some previous time. The latter are the ones that the predicate *former teacher* should be true of. In other words, *former teacher* is a predicate that is true of individuals just in case the predicate *teacher* was true of them at some previous time (and is not true of them now). To make this work, we need to make *teacher* a predicate whose extension varies from time to time and we need to make *former* into something that manipulates the time for which the extension of *teacher* is calculated.

We need to move to a semantics that is *intensional* in the following sense: (i) it has to contain operators, like *former*, that "displace" the evaluation of their complements from the actual here and now to other points of reference (spatially, temporally, and modally), (ii) the semantic values of constituents, like *teacher*, need to be sensitive to a point of reference that can be controlled by "displacement" operators.

To make the semantic values of predicates sensitive to what time they are to be evaluated at, there are two main options: (i) In a "true intensional" system, there is reference to and quantification over times in the meta-language which is used to state the lexical entries and composition rules, but there are no names or variables for times in the object language. (ii) In an "extensional intensional" system, there are time-variables and time-variable-binders that are part of the expressions of the object language. For the moment, we will adopt a true intensional system. There is, however, some potential empirical evidence that the "extensional" option is more appropriate for the semantics of natural language, and we will look at some of that later.

1.3 "former teacher"

Here are two lexical entries:

(6)   For any $t \in T$: $[\![teacher]\!]^t = \lambda x \in D$. x is a teacher at t

(7)   For any $t \in T$:
         $[\![former]\!]^t = \lambda f \in D_{<s,et>}$. $\lambda x \in D.[f(t)(x){=}0$ & $\exists t'$ before t: $f(t')(x) = 1]$

We assign interpretations/semantic values/extensions relative to a point in time. For any point in time, we get the set of individuals that are teachers at that time. The semantic value for *former* wants as its argument a function from times to sets. How does it get that? Let's build up the system more formally.

1.4 Intensional Domains

In what follows, let T be the set of all instants of time. Associated with each instant of time t is the domain of all individuals existing at t. Let D be the union of the domains of all instants of time. That is, D contains all individuals existing at the current time *plus* all individuals existing at any of the other times.

We expand the set of semantic types by adding a new basic type, the type s. We now have three basic types (e, t, and s), from which we can form an enriched set of derived (functional) types. The new set of domains is as follows:

(8) $D_s = T$, the set of all instants of time
         $D_e = D$, the set of all individuals existing at any time
         $D_t = \{0,1\}$, the set of truth-vales
         If a and b are semantic types, then $D_{<a,b>}$ is the set of all functions
         from D_a to D_b.

1.5 Lexical Entries

Extensions of predicates vary from one moment in time to the next. We capture this by relativizing the interpretation function to a time. The basic notion now

is $[\![\alpha]\!]^{t,g}$, i.e., the semantic value of the expression α with respect to the time t and the variable assignment g. "$[\![\alpha]\!]^g$" ("the semantic value of α under g"), "$[\![\alpha]\!]^t$" ("the semantic value of α at t"), or "$[\![\alpha]\!]$" ("the semantic value of α") are well-defined only under special conditions as abbreviations:

(9)   a.   If $[\![\alpha]\!]^{t,\emptyset}$ is defined (see H&K, ch. 5), then $[\![\alpha]\!]^t := [\![\alpha]\!]^{t,\emptyset}$.
         b.   If for any two t_1, $t_2 \in T$: $[\![\alpha]\!]^{t1,g} = [\![\alpha]\!]^{t2,g}$,
             then $[\![\alpha]\!]^g := [\![\alpha]\!]^{t,g}$ for all t∈T.
         c.   If $[\![\alpha]\!]^{\emptyset}$ is defined by clause (b), then $[\![\alpha]\!] := [\![\alpha]\!]^{\emptyset}$.

Lexical entries for "ordinary" ("extensional") predicates now look as follows:

(10)   For any t ∈ T:
         $[\![smart]\!]^t = \lambda x \in D.$ x is smart at t
         $[\![teacher]\!]^t = \lambda x \in D.$ x is a teacher at t
         $[\![likes]\!]^t = \lambda x \in D. [\lambda y \in D.$ y likes x at t]

Their extensions are of the familiar types <e,t> and <e,et> respectively.

For proper names, truth-functional connectives, and determiners, the abbreviation conventions in (9) allow us to write their entries in exactly the forms that we are familiar with from the extensional system. This is because these items have the same extension at every point in time.

(11)   a. $[\![Ann]\!] = $ Ann
         b. $[\![and]\!] = \lambda u \in D_t. \ \lambda v \in D_t.$ u=v=1
         c. $[\![the]\!] = \lambda f \in D_{<e,t>}: \exists!x \ [f(x) = 1].$ the y such that f(y) = 1.
         d. $[\![every]\!] = \lambda f \in D_{<e,t>}. \ \lambda g \in D_{<e,t>}. \forall x \ [f(x) = 1 \rightarrow g(x) = 1]$

The system starts earning its keep when we introduce "intensional" operators. We start with *former*:

(12) $[\![former]\!]^t = \lambda f \in D_{<s,et>}. \ \lambda x \in D.[f(t)(x)=0 \ \& \ \exists t'$ before t: f(t')(x) = 1]

This semantic value of *former* is of type <<s,et>,et>. Note that as its first argument, it is looking for a function from times to sets of individuals. Note also that we have no such functions yet. We'll get them soon.

1.6   Extensions and Intensions[1]

In our old extensional semantics, the notation "$[\![\alpha]\!]$" was read as "the semantic value of α", or equivalently "the extension of α". In the new, "intensional", system that we are now developing, semantic values still are extensions. "$[\![\alpha]\!]$"

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[1] We disregard assignment dependency in this subsection. If we consider expressions α that contain free variables, then, of course, both their extensions and their intensions will depend on the variable assignment. So we need an assignment superscript on the intension-brackets as well as on the extension-brackets (i.e., $[\![\alpha]\!]^{\mathbb{c},g} = \lambda t.[\![\alpha]\!]^{t,g}$, and "$[\![\alpha]\!]^{\mathbb{c}}$" is undefined in this case.)

("the semantic value of α") is now in general not well-defined, except when it makes sense to read it as "the extension that α has at every point of time". What is generally defined is "$\llbracket \alpha \rrbracket^t$", which we read as "the semantic value of α with respect to t" or equivalently as "the extension of α at t".

We can also define a notion of "intension" now. For an arbitrary expression α, the intension of α (notation: "$\llbracket \alpha \rrbracket_{\cancel{c}}$"[2]) is defined as follows:

(13) $\llbracket \alpha \rrbracket_{\cancel{c}} := \lambda t.\ \llbracket \alpha \rrbracket^t$

Thus the intension of an expression α is that function (with domain T) which maps every point of time to the extension of α at that time. Even though intensions are not themselves the semantic values of any LF-trees or subtrees, our semantics allows us to calculate intensions as well as extensions for all (interpretable) expressions.[3]

Since intensions are by definition not dependent on the choice of a particular time, it makes no sense to put a time-superscript on the intension-brackets. So don't ever write "$\llbracket \ldots \rrbracket_{\cancel{c}}^{t}$"; we'll treat that as undefined nonsense.

1.7   Composition Rules

We retain the old rules of Functional Application, Predicate Modification, and λ-Abstraction, with the trivial modification that each rule now must say "for every time t". For example:

(14)   *Functional Application (FA)*
        If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any time t and assignment g: if $\llbracket \beta \rrbracket^{t,g}$ is a function whose domain contains $\llbracket \gamma \rrbracket^{t,g}$, then $\llbracket \alpha \rrbracket^{t,g} = \llbracket \beta \rrbracket^{t,g} (\ \llbracket \gamma \rrbracket^{t,g}\ )$.

We also add the new rule of Intensional Functional Application.

(15)   *Intensional Functional Application (IFA)*
        If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any time t and assignment g: if $\llbracket \beta \rrbracket^{t,g}$ is a function whose domain contains $\llbracket \gamma \rrbracket_{\cancel{c}}^{g}$, then $\llbracket \alpha \rrbracket^{t,g} = \llbracket \beta \rrbracket^{t,g} (\ \llbracket \gamma \rrbracket_{\cancel{c}}^{g}\ )$.

Now, everything is in place for our sentence.

Exercise

Take our sentence (4) again:

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[2]The notation with the subscripted cent-sign comes from Montague Grammar. See e.g. Dowty, Wall & Peters, p. 147.

[3]There are also varieties of intensional semantics in which the semantic values *themselves* are intensions rather than extensions. Such systems are common in the literature (see e.g. Lewis 1970, Cresswell 1973), but the one we use for the time being is not of this sort.

(16)   John is a former teacher.

Draw an appropriate LF for the sentence and compute its truth-conditions. Treat *is* and *a* as semantically empty.

Start with: "For any time t , $[\![\ldots]\!]^t = 1$ iff $\ldots$" Recall that $[\![\ldots]\!]^t = [\![\ldots]\!]^{t,\emptyset}$, and that $\emptyset$ is the empty assignment. Convince yourself before you start that $[\![\ldots]\!]^{t,\emptyset}$ (and hence $[\![\ldots]\!]^t$) is well-defined in this case.

2   Tense (Part I)

2.1   Basics

In this framework, we can now formulate a very simple-minded first analysis of the present and past tenses and the future auxiliary *will*. As for (LF) syntax let's assume that (complete matrix) sentences are TPs, headed by T (for "tense"). There are two morphemes of the functional category T, namely *PAST* (past tense) and *PRES* (present tense). The complement of T is an MP or a VP. MP is headed by M (for "modal"). Morphemes of the category M include the modal auxiliaries *must*, *can*, etc. which we will talk about soon, the semantically vacuous *do* (in so-called "do-support" structures), and the future auxiliary *will*. Evidently, this is a semantically heterogeneous category, grouped together solely because of their common syntax (they are all in complementary distribution with each other). The complement of M is a VP. When the sentence contains none of the items in the category M, we assume that MP isn't projected at all; the complement of T is just a VP in this case. We thus have LF-structures like the following. (The corresponding surface sentences are given below, and we won't be explicit about the derivational relation between these and the LFs. Assume your favorite theories of syntax and morphology here.)

(17)   [TP Mary [T' PRES [VP t [V' be tired]]]]
         = Mary is tired.

(18)   [TP Mary [T' PAST [VP t [V' be tired]]]]
         = Mary was tired.

(19)   [TP Mary [T' PRES [MP t [M' woll [VP t [V' be tired]]]]]]
         = Mary will be tired.

When we have proper name subjects, we will pretend for simplicity that they are reconstructed somehow into their VP-internal base position. (We will talk more about reconstruction later on.)

What are the meanings of *PRES*, *PAST*, and *will*? For *PRES*, the simplest assumption is actually that it is semantically vacuous. This means that the interpretation of the LF in (17) is identical to the interpretation of the bare VP *Mary be tired*:

(20)   For any time t:
         $[\![PRES\ (Mary\ be\ tired)]\!]^t = [\![Mary\ be\ tired]\!]^t = 1$ iff Mary is tired at t.

Does this adequately capture the intuitive truth-conditions of the sentence *Mary is tired*? It does if we make the following general assumption:

(21)   An utterance of a sentence (= LF) ϕ that is made at a time t counts as true iff $[\![\phi]\!]^t = 1$ (and as false if $[\![\phi]\!]^t = 0$).

This assumption ensures that (unembedded) sentences are, in effect, interpreted as claims about the time at which they are uttered ("utterance time" or "speech time"). If we make this assumption and we stick to the lexical entries we have adopted, then we are driven to conclude that the present tense has no semantic job to do. A tenseless VP *Mary be tired* would in principle be just as good as (17) to express the assertion that Mary is tired at the utterance time. Apparently it is just not well-formed as an unembedded structure, but this fact must be attributed to principles of syntax rather than semantics.

What about *PAST*? When a sentence like (18) *Mary was tired* is uttered at a time t, then what are the conditions under which this utterance is judged to be true? A quick (and perhaps ultimately wrong) answer is: an utterance of (18) at t is true iff there is some time before t at which Mary is tired. This suggests the following entry:

(22)   For any instant t:
        $[\![PAST]\!]^t = \lambda p \in D_{<s,t>}.\ \exists t'$ before t: p(t') = 1

So, the past tense seems to be an existential quantifier over times, restricted to times before the utterance time.

For *will*, we can say something completely analogous:

(23)   For any instant t:
        $[\![will]\!]^t = \lambda p \in D_{<s,t>}.\ \exists t'$ after t: p(t') = 1

Apparently, *PAST* and *will* are semantically alike, even mirror images of each other, though they are of different syntactic categories. The fact that *PAST* is the topmost head in its sentence, while *will* appears below *PRES*, is due to the fact that syntax happens to require a T-node in every complete sentence. Semantically, this has no effect, since *PRES* is vacuous.

Both (21) and (22) presuppose that the set T comes with an intrinsic order. For concreteness, assume that the relation 'precedes' (in symbols: <) is a strict linear order on T.[4] The relation 'follows', of course, can be defined in terms of 'precedes' (t follows t' iff t' precedes t).

There are many things wrong with this simple analysis. We will not have time here to diagnose most of the problems, much less correct them. But let's see a couple of things that work out OK and let's keep problems and remedies for later.

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[4]Definition: A relation R is a strict linear order on a set S iff it has the following four properties:
(i) $\forall x \forall y \forall z$ ((Rxy & Ryz) → Rxz) "Transitivity"
(ii) $\forall x$ (¬Rxx) "Irreflexivity"
(iii) $\forall x \forall y$ (Rxy → ¬Ryx) "Asymmetry", and
(iv) $\forall x \forall y$ (x ≠ y → (Rxy ∨ Ryx)) "Connectedness"

2.2 Some Time Adverbials

At least to a certain extent, we can also provide a treatment of temporal adverbials such as:

(24)   Mary was tired on February 1, 2001.

The basic idea would be that phrases like *on February 1, 2001* are propositional modifiers. Propositions are the intensions of sentences. At this point, propositions are functions from times to truth-values. Propositional modifiers take a proposition and return a proposition with the addition of a further condition on the time argument.

(25) $[\![on\ February\ 1,\ 2001]\!]^t$
        $= \lambda p \in D_{\langle s,t \rangle}.\ [\ p(t) = 1\ \&\ t$ is part of Feb 1, 2001 $]$

(26)   [T' PAST [$_{VP}$ [$_{VP}$ Mary [$_{V'}$ be tired]] [$_{PP}$ on February 1, 2001]]]

An alternative would be to treat *on February 1, 2001* as a "sentence" by itself, whose intension then would be a proposition.

(27) $[\![on\ February\ 1,\ 2001]\!]^t = 1$ iff t is part of February 1, 2001

(28) $[\![on]\!]^t = \lambda x.$ t is part of x

To make this work, we would then have to devise a way of combining two tenseless sentences (*Mary be tired* and *on February 1, 2001*) into one. We could do this by positing a silent *and* or by introducing a new composition rule ("Propositional Modification"?).

Let's not spend time on such a project. We'll come back to temporal adverbials during our second pass through matters of time and tense later.

Exercise 2

Imagine that *Mary was tired on February 1, 2001* is not given the LF in (26) but this one:

(29)   [$_{T'}$ [$_{T'}$ PAST [$_{VP}$ Mary [$_{V'}$ be tired]]] [$_{PP}$ on February 1, 2001]]

What would the truth-conditions of this LF be? Does this result correspond at all to a possible reading of this sentence (or any other analogous sentence)? If not, how could we prevent such an LF from being produced?

Exercise 3: Quantifiers in Tensed Sentences

When a quantifier appears in a tensed sentence, we might expect two scope construals. Consider a sentence like this:

(30)   Every professor (in the department) was a teenager in the Sixties.

We can imagine two LFs:

(31)   PAST [[every professor be a teenager] [in the sixties]]

(32)   [every professor] λ2 [PAST [[t$_2$ be a teenager] [in the sixties]]

Describe the different truth-conditions which our system assigns to the two LFs.
Is the sentence ambiguous in this way?

If not this sentence, are there analogous sentences that do have the ambiguity?

Exercise 4

We gave the following entry for *every*:

(33) $\llbracket every \rrbracket = \lambda f \in D_{<e,t>}.\ \lambda g \in D_{<e,t>}.\forall x\ [\ f(x) = 1 \rightarrow g(x) = 1\ ]$

Consider now two possible variants (we have underlined the portion where they
differ):

(34) $\llbracket every \rrbracket^t = \lambda f \in D_{<e,t>}.\ \lambda g \in D_{<e,t>}.\forall x\ at\ t\ [\ f(x) = 1 \rightarrow g(x) = 1\ ]$

(35) $\llbracket every \rrbracket^t = \lambda f \in D_{<e,t>}.\ \lambda g \in D_{<e,t>}.\forall x\ [\ f(x) = 1\ at\ t \rightarrow g(x) = 1\ at\ t\ ]$

Does either of these alternative entries make sense? If so, what does it say? Is
it equivalent to our official entry? Could it lead to different predictions about
the truth-conditions of English sentences?

2.3   A Word of Caution

Compare the semantics given for *former* and the one for *PAST*:

(36)   a. $\llbracket former \rrbracket^t = \lambda f \in D_{<s,et>}.\ \lambda x \in D.[f(t)(x)=0\ \&\ \exists t'$ before t: $f(t')(x)$
             $= 1\ ]$
         b. $\llbracket PAST \rrbracket^t = \lambda p \in D_{<s,t>}.\ \exists t'$ before t: $p(t') = 1$

Notice that these entries have an interesting consequence:

(37)   a. John is a former teacher.
         b. John was a teacher.

The two sentences in (37) differ in their truth-conditions. The sentence in (a)
can only be true if John is not a teacher anymore while this is not part of
the truth-conditions of the sentence in (b). To see that this analysis is in fact
correct, consider this:

(38)   Last night, John was reading a book about tense.
         a. !! The authors are former Italians.
         b. The authors were Italian.

Consider the past tense in the (b) sentence. It is not (necessarily) interpreted as claiming that the authors are not Italian anymore. But this is in fact required by the (a) sentence.

There are some cases where it seems that the past tense does trigger inferences that one would not expect from the lexical entry that we gave. Surely, if I tell you *My cousin John was a teacher* you will infer that he isn't a teacher anymore. In fact, you may even infer that he is not alive anymore. One promising approach that tries to reconcile a semantics like ours with the possibility of stronger inferences in some contexts is based on pragmatic considerations:

Musan, Renate: 1997. Tense, Predicates, and Lifetime Effects. *Natural Language Semantics* 5: 271-301.

Examples like the one in (38) are problematic for widely held naive conceptions of what the past tense means. One often hears that *PAST* expresses the fact that "the time of the reported situation precedes the speech time". If this were to mean that the time of the book's authors being Italian precedes the speech time, this would presumably wrongly predict that they would have to be not Italian anymore for the sentence to be true (or usable).

3   Modality

We turn to modal displacement. Further examples of modal constructions include these (see Kratzer 1991a):

(39)   New structures must be generated.
         New structures can be generated.
         This is not absolutely impossible.
         This is a remote possibility.
         Possibly, we will return soon.
         Such thoughts are not expressible in any human language.
         This can opens at the top.
         This car goes twenty miles an hour.
         This book reads well.
         Bears like honey.

The realm of modal reference points that we will use is the set of "possible worlds". For now, we will not combine this with our previous temporal system. Pretend that modal displacement is all the intensionality we need to deal with.

David Lewis (1986, *On the Plurality of Worlds*, p1f) on possible worlds:

> 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.

For more on the foundations of possible worlds semantics:

Loux, Michael, ed. 1979 *The Possible and the Actual: Readings in the Metaphysics of Modality.* Ithaca: Cornell University Press.

3.1   Technical Set-Up

We have already seen how to set up an intensional system. Here we just need to transfer everything into a system that relativizes meaning to possible worlds. This and the following subsections merely summarize ch. 12.3 (pp. 303 - 309) of H&K (with some minor technical differences). They are therefore short on prose – you have the book.

3.1.1   Intensional Domains

In what follows, let W be the set of all possible worlds. Associated with each possible world w is the domain of all individuals existing in w. Let D be the union of the domains of all possible worlds. That is, D contains all individuals existing in the actual world *plus* all individuals existing in any of the merely possible worlds. It is the set of all possible individuals.

We expand the set of semantic types by adding a new basic type, the type s. We now have three basic types (e, t, and s), from which we can form an enriched set of derived (functional) types. The new set of domains is as follows:

(40) D_s = W, the set of all possible worlds
         D_e = D, the set of all possible individuals

$D_t = \{0,1\}$, the set of truth-vales

If a and b are semantic types, then $D_{<a,b>}$ is the set of all functions from D_a to D_b.

3.1.2 Lexical Entries

Extensions of predicates vary with possible worlds. We capture this by relativizing the interpretation function to a possible world. The basic notion now is $[\![\alpha]\!]^{w,g}$, i.e., the semantic value of the expression α with respect to the world w and the variable assignment g. "$[\![\alpha]\!]^g$" ("the semantic value of α under g"), "$[\![\alpha]\!]^w$" ("the semantic value of α in w"), or "$[\![\alpha]\!]$" ("the semantic value of α") are well-defined only under special conditions as abbreviations:

(41)   a.   If $[\![\alpha]\!]^{w,\emptyset}$ is defined (see H&K, ch. 5), then $[\![\alpha]\!]^w := [\![\alpha]\!]^{w,\emptyset}$.

   b.   If for any two w_1, $w_2 \in W$: $[\![\alpha]\!]^{w1,g} = [\![\alpha]\!]^{w2,g}$, then $[\![\alpha]\!]^g := [\![\alpha]\!]^{w,g}$ for all $w \in W$.

   c.   If $[\![\alpha]\!]^{\emptyset}$ is defined by clause (b), then $[\![\alpha]\!] := [\![\alpha]\!]^{\emptyset}$.

Lexical entries for "ordinary" ("extensional") predicates now look as follows:

(42)   a.   For any $w \in W$: $[\![smart]\!]^w = \lambda x \in D.\ x$ is smart in w
   b.   For any $w \in W$: $[\![likes]\!]^w = \lambda x \in D.\ [\lambda y \in D.\ y$ likes x in w]

Their extensions are of the familiar types <e,t> and <e,et> respectively.

For proper names, truth-functional connectives, and determiners, the abbreviation conventions allow us to write their entries in exactly the forms that we are familiar with from the extensional system. This is because these items have the same extension in every possible world.

(43)   a. $[\![Ann]\!]$ = Ann
   b. $[\![and]\!] = \lambda u \in D_t.\ [\ \lambda v \in D_t.\ u = v = 1]$
   c. $[\![the]\!] = \lambda f \in D_{<e,t>}: \exists !x.\ f(x) = 1.$ the y such that $f(y) = 1$.
   d. $[\![every]\!] = \lambda f \in D_{<e,t>}.\ \lambda g \in D_{<e,t>}.\forall x\ [\ f(x) = 1 \rightarrow g(x) = 1]$

3.1.3 Extensions and Intensions

In our old extensional semantics, the notation "$[\![\alpha]\!]$" was read as "the semantic value of α", or equivalently "the extension of α (in the actual world)". In the new, "intensional", system that we are now developing, semantic values still are extensions. "$[\![\alpha]\!]$" ("the semantic value of α") is now in general not well-defined, except when it makes sense to read it as "the extension that α has in every possible world". What is generally defined is "$[\![\alpha]\!]^w$", which we read as "the semantic value of α with respect to w" or equivalently as "the extension of α in w".

We can also define a notion of "intension" now. For an arbitrary expression α, the intension of α (notation: "$[\![\alpha]\!]_{\not{c}}$") is defined as follows:

(44) $[\![\alpha]\!]_{\not{c}} := \lambda w.\ [\![\alpha]\!]^w$

Thus the intension of an expression α is that function (with domain W) which maps every possible world to the extension of α in that world. Even though intensions are not themselves the semantic values of any LF-trees or subtrees, our semantics allows us to calculate intensions as well as extensions for all (interpretable) expressions.

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 "$[\![\ldots]\!]_{\not{c}}^{w}$"; we'll treat that as undefined nonsense.

3.1.4   Composition rules

We retain the old rules of Functional Application, Predicate Modification, and λ-Abstraction, with the trivial modification that each rule now must say "for every world w". For example:

(45)   *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 $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}\ (\ [\![\gamma]\!]^{w,g}\ )$.

We also add the new rule of Intensional Functional Application.

(46)   *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 $[\![\gamma]\!]_{\not{c}}^{g}$, then $[\![\alpha]\!]^{w,g} = [\![\beta]\!]^{w,g}\ (\ [\![\gamma]\!]_{\not{c}}^{g}\ )$.

3.2   Modal Predicates as Quantifiers over Worlds

3.2.1   Syntactic structures

We will be looking here not just at the modal auxiliaries (*must, may, should, can, . . .*), but also at infinitive-embedding main verbs and adjectives like *have to, need to, be supposed to, be likely to . . .*. Glossing over many syntactic details, the modal auxiliaries embed VPs and the main verbs/adjectives embed infinitive IPs. Adopting the VP-internal subject hypothesis[5], these two types of complements don't differ in semantic type. In fact, we will assume here that there is no semantic import to any of the additional structure that distinguishes

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[5]For the time being, the motivation for this assumption is independent of our current concerns. See, for example, the discussion of quantifier scope in ch. 8.4 of H&K. But we will take up the issue of the relative position of modals and subjects more seriously below.

a full infinitival clause from a bare VP. We will also assume, at least for the time being, that the main verbs and adjectives in question are all raising predicates (rather than control predicates), i.e., their subjects are not their own arguments, but have been moved from the subject-position of their infinitival complements.[6] Given all this, the structures projected by the auxiliaries and the main verbs/adjectives are essentially the same, apart from semantically vacuous material that we can ignore:

(47)   a.   you must stay
        b.   [$_{IP}$ you [λ_1 [$_{I'}$ must [$_{VP}$ t$_1$ stay]]]]

(48)   a.   you have to stay
        b.   [$_{IP}$ you [λ_1 [PRES [t$_1$ λ_2 [have [t$_2$ λ_3 [to [t$_3$ stay]]]]]]]]

Actually, we will be working here with the even simpler structures 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.[7]) 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 structures in (47) and (48) would be the same as of (49) and (50). 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.

(49)   must [you stay]

(50)   PRES [have-to [you stay]]

3.2.2   Interpretation

To make LFs like those above interpretable by our composition rules, we have to assume that the extensions of modal predicates are functions in either D$_{<t,t>}$ (truth-values to truth-values) or D$_{<st,t>}$ (propositions to truth-values).

If they were of type <t,t>, modal predicates would create extensional contexts. By the sort of argument we have seen above, we can show that this is not so. For example, suppose that you do in fact stay, and you also do in fact watch TV. So the truth-values (extensions) of the clauses *you stay* and *you watch TV* are the same (both are 1). Still, it may very well be true that you must stay, but false that you must watch TV.

So we are left with type <st,t> for the modal predicate. This is, in effect, the type of generalized quantifiers over possible worlds. (Compare type <et,t> for quantifiers over individuals.)

Indeed, an elementary intuition about the meanings of *must* and *may* is that they can be seen as expressing, respectively, a universal quantification and an existential quantification over possibilities: *You must stay* means (roughly) that

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[6]The issue of raising vs. control will be taken up later.

[7]We will talk about reconstruction in more detail later.

you stay in all the acceptable (allowable, legal) possible scenarios under consideration. *You may stay* means that you stay in at least some of the acceptable possible scenarios (but there can be other acceptable possibilities in which you don't stay). As a first stab at the meanings of *must*, *may*, etc., then, we may write down these two (sets of) lexical entries:

(51)   Let C ⊆ W be the set of relevant acceptable worlds. Then

      a. $[\![must]\!] = [\![have\text{-}to]\!] = [\![need\text{-}to]\!] = \ldots =$
          $\lambda p \in D_{<s,t>}.\forall w \in C: p(w){=}1$ (in set talk: $C \subseteq p$)

      b. $[\![may]\!] = [\![can]\!] = [\![be\text{-}allowed\text{-}to]\!] = \ldots =$
          $\lambda p \in D_{<s,t>}.\exists w \in C: p(w){=}1$ (in set talk: $p \cap C \neq \emptyset$)

We now predict (using IFA) that the LF for *you must stay* in (49) is true iff you stay in every world in C. And the corresponding sentence with *may* is predicted true iff you stay in some world in C.

3.2.3 Inferences

This analysis is crude for a couple of reasons that we will turn to presently. But it does 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:

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

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

(54)   a.   You may stay, but it is not the case that you must stay.[8]

      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:

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[8]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 > 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.) 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.

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

(56)   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.

(57)   a.   You must stay.

        b.   It is not the case that you may leave.
              You aren't allowed to leave.
              (You may not leave.)[9]
              (You can't leave.)

(58)   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.)

Given that *stay* and *leave* are each other's negations (i.e. $[\![leave]\!] = [\![not\ stay]\!]$, and $[\![stay]\!] = [\![not\ leave]\!]$), the LF-structures of these equivalent pairs of sentences can be seen to instantiate the following schemata:[10]

(59)   a.   *must $\phi \equiv$ not [may [not ϕ]]*
        b.   *must [not ψ] $\equiv$ not [may ψ]*

(60)   a.   *may $\phi \equiv$ not [must [not ϕ]]*
        b.   *may [not ψ] $\equiv$ not [must ψ]*

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. For example, the schemata above turn out to be exactly parallel to, and valid for the same reason as, the following familiar equivalences of Predicate Logic.

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

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

---

[9]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.

[10]In logicians' jargon, *must* and *may* behave as "duals" of each other. For definitions of "dual", see Barwise & Cooper (1981), p. 197; or volume 2 of Gamut (1991), p. 238.

More linguistic data regarding the "parallel logic" of modals and quantifiers:

Horn, Larry: 1972 *On the Semantic Properties of Logical Operators in English.*
Ph.D. Dissertation, UCLA; distributed by IULC 1976.

3.3   Restricted Quantification over Worlds

There are, however, two problems with the lexical entries in (51). First, these
entries seem to be tailored to one particular reading of the modals in question,
the so-called "deontic" reading. What about other readings, such as "epistemic"
readings, or readings that pertain to abilities, dispositions, and so on? We need
a more general treatment.

The second problem is that the current analysis predicts that sentences with
modals are *non-contingent*, that is, they are predicted to be true no matter
what world they are asserted in. But that is not correct: we can imagine cir-
cumstances under which it is true that you must be quiet and also circumstances
under which it is false. This problem can be given an especially dramatic illus-
tration by sentences that embed one modal predicate under another:

(63)   It might be the case that you must leave.
          You might have to leave.
          "It is compatible with what I know that the only way to attain your
          goal is to leave".

3.3.1   Context-dependency

Let us begin with the first problem. Traditional descriptions of modals often
distinguish a number of readings: "epistemic," "deontic," "ability," "circum-
stantial," "dynamic,"... (Beyond "epistemic" and "deontic," there is a great
deal of terminological variety. Sometimes all non-epistemic readings are grouped
together under the term "root".) Here are some initial illustrations.

(64)   A: Where is John?
          B: I don't know. He *may* be at home. ("epistemic")

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

(66)   A: I will plant the rhododendron here.
          B: That's not a good idea. It *can grow very tall.*
          ("circumstantial" or "dynamic")

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

(65) is similar to the examples we considered in the last section. Applying the
entry in (51), *you may bring her here for dinner* means that there is some world
in C in which you bring her here for dinner. What is C? We characterized it as

the set of "acceptable" or "allowable" worlds. What set exactly is that? Well, if (65) is a dialogue between a child and her mother, then apparently C here is intended (and understood) to be the set of those possible worlds which conform to the rules laid down by the mother (i.e., those worlds in which everyone acts in compliance with those rules).

What about example (64)? Here we understand *he may be at home* to mean something like "it is compatible with what I know that he is home". We can capture this by applying essentially the same entry (51), except that now we define C as the set of possible worlds that conform to the speaker's knowledge (i.e., those worlds in which nothing is the case that the speaker knows is not the case). The utterance *he may be at home* then asserts that there are some worlds which conform to the speaker's knowledge and in which John is at home.

The example in (66) also can be seen as an existential quantification over a certain set of possible worlds. Here the set that takes the place of "C" in entry (51) seems to be the set of worlds which conform to the laws of nature (in particular, plant biology). What the speaker here would be 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.)

If these analyses are on the right track, our lexical entries from (51) can pretty much stand as they are. The only refinement needed is more flexibility in the determination of the set C. Maybe this can in principle be any set of worlds whatsoever. It just needs to be salient somehow in the utterance situation in which the modalized sentence is used. The different so-called "readings" of the modals then are not really different readings of these lexical items, but rather result from different ways of resolving a hidden context-dependency.

We encountered context-dependency before when we talked about pronouns and their referential (and E-Type) readings. 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:

(67) $[_{\mathrm{I'}}$ $[_{\mathrm{I}}$ must $p_{\mathbf{<s,t>}}]$ $[_{\mathrm{VP}}$ you quiet$]]$

$p_{\mathbf{<s,t>}}$ 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 $<st,<st,t>>$ rather than $<st,t>$, thus more like that of 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 $<st,t>$.

(68)   a. $\llbracket must \rrbracket = \llbracket have\text{-}to \rrbracket = \llbracket need\text{-}to \rrbracket = \ldots =$
              $\lambda p \in D_{<s,t>}.\ \lambda q \in D_{<s,t>}.\ \forall w \in W\ [p(w)=1 \rightarrow q(w)=1]\ (p \subseteq q)$

        b. $\llbracket may \rrbracket = \llbracket can \rrbracket = \llbracket be\text{-}allowed\text{-}to \rrbracket = \ldots =$
              $\lambda p \in D_{<s,t>}.\ \lambda q \in D_{<s,t>}.\ w \in W\ [p(w)=1\ \&\ q(w)=1]\ (p \cap q \neq \emptyset)$

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

(69)   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.)

Exercise 5

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.

3.3.2   Epistemic vs. Circumstantial Modality: Kratzer's Example[11]

Consider sentences (70) and (71):

(70)   Hydrangeas can grow here.

(71)   There might be hydrangeas growing here.

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

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[11] Quoted from A. Kratzer (1991) "Modality." In Arnim von Stechow and Dieter Wunderlich, eds., *Semantics: An International Handbook of Contemporary Research.* Berlin: Walter de Gruyter, pp. 639-650.

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 (70). In such a situation, the proposition expressed by (70) 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 (71) would express a false proposition. What counts here is the complete evidence available. And this evidence is not compatible with the existence of hydrangeas.

(70) together with our scenario illustrates the pure *circumstantial* reading of the modal *can*. [...]. (71) 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.

3.3.3   Contingency

The above amendment addresses the "ambiguity" problem, but we still have the problem of non-contingency. Let's take a closer look at how this problem arises. When we interpret a tree like (67), we first use FA to obtain $[\![must]\!](g_c(p))$[12], and then IFA to obtain $[\![must]\!](g_c(p))(\lambda w'.[\![you\ quiet]\!]^{w'})$. It is apparent that this expression picks out a unique truth-value, independently of the evaluation world that we have chosen for the whole sentence.

To pinpoint the intuitive source of the problem, let us concentrate on a particular deontic reading of (67), say, 'you must be quiet to conform to the house rules'. 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 must be quiet* may be true or it may be false.

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[12] g_c is the contextually supplied variable assignment, and $g_c(p)$ is thus the contextually salient set of worlds over which the modal quantifies.

Why does our current analysis fail to capture this contingency? 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* 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 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 <s,st>.

(72) $[_{\text{I'}} [_{\text{I}} \text{ must } \text{R}_{<s,st>}] [_{\text{VP}} \text{ you quiet}]]$

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

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

      a. $[\![must]\!]^w = [\![have\text{-}to]\!]^w = [\![need\text{-}to]\!]^w = \ldots =$
            $\lambda R \in D_{<s,st>}. \ \lambda q \in D_{<s,t>}. \ \forall w' \in W \ [R(w)(w') = 1 \rightarrow q(w')=1]$
            $(R(w) \subseteq q)$

      b. $[\![may]\!]^w = [\![can]\!]^w = [\![be\text{-}allowed\text{-}to]\!]^w = \ldots =$
            $\lambda R \in D_{<s,st>}. \ \lambda q \in D_{<s,t>}. \ w' \in W \ [R(w)(w')=1 \ \& \ q(w')=1]$
            $(R(w) \cap q \neq \emptyset)$

Let us see now how this solves the contingency problem. Notice that, in contrast to the two previous sets of lexical entries, the ones in (73) show a world-superscript on the semantic-value brackets around the modal. In other words, we now acknowledge that the modal's extension varies from one evaluation world to the next. This, as we see in the calculation below, is the key to predicting contingency for the modalized sentence as a whole.

(74)   Let w be a world, and let c be a context such that
      $g_c(R) = \lambda w. \ \lambda w'. \ \text{the house rules in force in w are obeyed in w'}$
      $[\![must \ R \ you \ quiet]\!]^{w,gc} = (\text{by IFA})$
      $[\![must \ R]\!]^{w,gc} \ (\lambda w' \ [\![you \ quiet]\!]^{w'}) = (\text{by FA})$

$\llbracket must \rrbracket^w$ ($\llbracket R \rrbracket^{gc}$) ($\lambda$w' $\llbracket you\ quiet \rrbracket^{w'}$) = (by lex. entries *you, quiet*)
$\llbracket must \rrbracket^w$ ($\llbracket R \rrbracket^{gc}$) ($\lambda$w'. you are quiet in w') = (by lex. entry *must*)
$\forall$w'$\in$W $\llbracket R \rrbracket^{gc}$(w)(w') =1 $\rightarrow$ you are quiet in w'] = (by def. of g$_c$)
$\forall$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 (74), the truth-value of (72) depends on the evaluation world w.

Exercise 6

Describe two worlds w$_1$ and w$_2$ so that $\llbracket must\ R\ you\ quiet \rrbracket^{w1,gc} = 1$ and $\llbracket must\ R\ you\ quiet \rrbracket^{w2,gc} = 0$.

Exercise 7

In analogy to the deontic relation g$_c(R)$ defined in (74), define an appropriate relation that yields an epistemic reading for a sentence like *You may be quiet*.

3.3.4   Contingency and Iteration

Recall our earlier example in:

(75)   You might have to leave.

It is time to show that we now know how to deal with it. 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 you attain the goals that you have in w' is such that you leave in w''.

Assume the following LF:

(76)   [$_{I'}$ [might R$_1$] [$_{VP}$ [have-to R$_2$] [$_{IP}$ 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 you attain the goals you have in w'. *have to* says that all of those worlds are worlds w'' in which you leave.

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

Are *epistemic* modals also contingent and embeddable?

Iatridou, Sabine: 1990 "The Past, the Possible, and the Evident." *Linguistic Inquiry 21*: 123-129.

von Fintel, Kai, & Sabine Iatridou: 2001 "On the Interaction of Modals, Quantifiers, and *If*-Clauses." ms. MIT

Exercise 8

Describe values for the covert <s,st>-variable that are intuitively suitable for the interpretation of the modals in the following sentences:

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

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

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

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

(81)   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 9

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 <s,st>-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.)

3.3.5   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 <<s,st>, <st,t>>:

(82)   (repeated from earlier):
        For any w ∈ W:
        $\llbracket must \rrbracket^w = \lambda R \in D_{<s,st>}.\ \lambda q \in D_{<s,t>}.\ \forall w' \in W\ [R(w)(w') =1 \rightarrow q(w')=1]$
        (in set talk: $\lambda R \in D_{<s,st>}.\ \lambda q \in D_{<s,t>}.\ R(w) \subseteq q$)

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

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

(83)   (repeated from even earlier):
$[\![must]\!] = \lambda p \in D_{<s,t>}.\ \lambda q \in D_{<s,t>}.\ \forall w' \in W\ [p(w') = 1 \rightarrow q(w') = 1]$
(in set talk: $\lambda p \in D_{<s,t>}.\ \lambda q \in D_{<s,t>}.\ p \subseteq q$)

We posit the following LF-representation:

(84) $[_{I'}\ [_{I}\ must\ [\ R_{<4,<s,st>>}\ w^*]]\ [_{VP}\ you\ quiet]]$

What is new here is that the covert restrictor is complex. The first part, $R_{<4,<s,st>>}$, is (as before) a free variable of type <s,st>, 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:[13]

(85)   For any $w \in W$: $[\![w^*]\!]^w = w$.

When $R_{<4,<s,st>>}$ and w^* combine (by Functional Application), we obtain a constituent whose extension is of type <s,t> (a proposition or set of worlds). This is the same type as the extension of the free variable C in the previous proposal, hence suitable to combine with the old entry for *must* (by FA). However, while the extension of C 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:

(86)   For any $w \in W$ and any assignment a:
$[\![R_{<4,<s,st>>}\ w^*]\!]^{w,a} = a(<4,<s,st>>)(w)$.

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 (84) is contingent.

Maybe this variant is more appealing. But in the text below, we continue to assume the original analysis as presented earlier.

3.4   Accessibility Relations and Related Concepts

The quantificational analysis of modal operators that we have presented so far was first developed around the 1950s in work by the philosophers Carnap, Kanger, Hintikka, and Kripke:

Carnap, Rudolf: 1947 *Meaning and Necessity*. Chicago: Chicago University Press.

Kanger, Stig: 1957 "The Morning Star Paradox." *Theoria 23*: 1-11.

Hintikka, Jaako: 1961 "Modality and Quantification." *Theoria 27*: 119-128. [Considerably Expanded Version Published in Jaako Hintikka: 1969. *Models for Modalities*. Dordrecht: Reidel. pp. 57-70.]

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[13]David Dowty (in "Tenses, Time Adverbs, and Compositional Semantic Theory," *L&P* 5, 1982, p. 24) introduced an analogous symbol to pick out the evaluation *time*. We have chosen the star-notation to allude to this precedent.

Kripke, Saul: 1959 "A Completeness Theorem in Modal Logic." *Journal of Symbolic Logic 24*: 1-14.

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

The free variables that we have introduced as the modals' restrictors in our LFs are variables of type <s,<s,t>>. So their possible values are essentially *binary relations between possible worlds* (abstracting away from schönfinkelization). In the tradition of philosophical logic, these are known as "accessibility relations". There are various aspects of the accessibility relations restricting modal operators that we can study, in particular (i) formal properties of the relations and how these affect the validity of inference patterns involving modalized sentences, and (ii) the manner in which context supplies clues as to what relation the speaker intends.

3.4.1   Reflexivity

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

(87) $R_1 := \lambda w.\ \lambda w'.$ w' is compatible with what the speaker knows in w.

We are asking whether for any given possible world w, we know that R_1 holds between w and w. It will hold if w is a world that is compatible with what we know in w. And clearly that must be so. Take our body of knowledge in w. The concept of knowledge crucially contains the concept of truth: what we know must be true. So if in w we know that something is the case then it must be the case in w. So, w must be compatible with all we know in w. R_1 is reflexive. We can therefore infer:

(88) $\forall w\ \forall p\ [\ [\![must]\!]^w(R_1)(p)=1 \rightarrow p(w)=1]$

For any world w and any proposition p, if in w p must be true (relative to R_1), then in w p *is* true.

If we consider a relation R_2 defined as giving as for any world w those worlds w' which are compatible with what we *believe* in w, we no longer have reflexivity. Here's a quote from David Lewis on this matter (1986, *On the Plurality of Worlds*, p. 27):

> The content of someone's knowledge of the world is given by his class
> of *epistemically accessible* worlds. These are the worlds that might,
> for all he knows, be his world; world w is one of them iff he knows
> nothing, either explicitly or implicitly, to rule out the hypothesis that
> w is the world where he lives. Likewise the content of someone's
> system of belief about the world (encompassing both belief that
> qualifies as knowledge and belief that fails to qualify) is given by

his class of *doxastically accessible* worlds. World w is one of those iff he believes nothing, either explicitly or implicitly, to rule out the hypothesis that w is the world where he lives.

What is true at some epistemically or doxastically accessible world is epistemically possible for him. It might be true, for all he knows or for all he believes. He does not know or believe it to be false. Whatever is true throughout the epistemically or doxastically accessible world is epistemically or doxastically necessary; which is to say that he knows or believes it, perhaps explicitly or perhaps only implicitly.

Since only truths can be known, the knower's own world always must be among his epistemically accessible worlds. Not so for doxastic accessibility. If he is mistaken about anything, that is enough to prevent his own world from conforming perfectly to his system of belief.

Similarly, reflexivity is not a property of deontic accessibility relations, such as R_3:

(89)　　$R_3 := \lambda w. \; \lambda w'. \;$ w' is a world in which you attain the goals that you have in w.

Unfortunately, for a given world w, w is not automatically a world in which you attain the goals that you have in w.[14]

Exercise 10

What about circumstantial accessibility relations? Are they reflexive? (Consider Kratzer's "hydrangeas" example from above.)

3.4.2　Symmetry

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

(90)　　Brouwer's Axiom:
　　　　$\forall p \; \forall w \; [w \in p \rightarrow [\forall w' \; [w' \in R(w) \rightarrow \exists w'' \; [w'' \in R(w') \; \& \; w'' \in p]]]$

Here's the reasoning: Suppose p is true in w. Pick some arbitrary accessible world w', i.e. w'∈R(w). Since R is assumed to be symmetric, we then have w∈R(w') as well. By assumption, p is true in w, and since w is accessible from w', this means that p is true in a world accessible from w'. In other words, $\exists w'' [w'' \in R(w') \; \& \; w'' \in p]$. Since p and w were arbitrary, and w' was an arbitrary world accessible from w, this establishes (85).

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[14]The property of reflexivity of accessibility relations can also be related to the notion of *centering*, defined by Lewis in his work on conditionals. From a given world w, the set of accessible worlds $\lambda w'.R(w)(w')$ is *centered* iff it contains w. This is equivalent to the condition that R be reflexive.

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

In the case of a knowledge-based accessibility relation (epistemic accessibility), one can argue in this way that *symmetry does not hold*:[15]

The symmetry condition would imply that if something is true, then you know that it is compatible with your knowledge (Brouwer's Axiom). This will be violated by any case in which your beliefs are consistent, but mistaken. Suppose that while p is in fact true, you feel certain that it is false, and so think that you know that it is false. Since you think you know this, it is compatible with your knowledge that you know it. (Since we are assuming you are consistent, you can't both believe that you know it, and know that you do not). So it is compatible with your knowledge that you know that not-p. Equivalently[16]: you don't know that you don't know that not-p. Equivalently: you don't know that it's compatible with your knowledge that p. But by Brouwer's Axiom, since p is true, you would have to know that it's compatible with your knowledge that p. So if Brouwer's Axiom held, there would be a contradiction. So Brouwer's Axiom doesn't hold here, which shows that epistemic accessibility is not symmetric.

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

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

Hughes, George and Max Cresswell: 1996 *A New Introduction to Modal Logic*. London: Routledge.

Exercise 10

What can you say about the mathematical properties of the accessibility relation R that you would need to assume to make the following hold?

(91) $\forall w \, \forall p \, [p(w){=}1 \rightarrow [\![can]\!]^w(R)(p) = 1]$

Once you have found the mathematical property at stake, can you think of natural examples that show *can* behave this way and of others where it doesn't?

3.4.3   Kratzer's Conversational Backgrounds

Kratzer, Angelika

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[15]Thanks to Bob Stalnaker (pc to Kai von Fintel) for help with the following reasoning.
[16]This and the following step rely on the duality of necessity and possibility: q is compatible with your knowledge iff you don't know that not-q.

1977 "What *Must* and *Can* Must and Can Mean." *Linguistics and Philosophy 1*: 337-355.

1978 *Semantik der Rede: Kontexttheorie - Modalwörter - Konditionalsätze.* Königstein/Taunus: Scriptor.

1981 "The Notional Category of Modality." In H.J. Eikmeyer and H. Rieser, eds., *Words, Worlds, and Contexts. New Approaches in Word Semantics.* Berlin: de Gruyter. 38-74.

1991 "Modality." In Arnim von Stechow and Dieter Wunderlich, eds., *Semantik: Ein internationales Handbuch der zeitgenössischen Forschung.* Berlin: Walter de Gruyter.K 639-650.

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 a phrase like *what the law provides, what we know*, etc. (More precisely, as we will show below, a conversational background corresponds to the intension of such a phrase.) 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 <s,<st,t>>, functions from worlds to (characteristic functions of) sets of propositions.

Now, consider:

(92)   (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. Since we don't quite have all the tools to actually compute the meaning of *what we know* compositionally, we will focus on the case of pure context-dependency. (As soon as we have talked about the semantics of attitude verbs like *know*, we will come back to the analysis of *what we know*.)

How do we get from a conversational background to an accessibility relation? Take the conversational background at work in (92). It will be the following:

(93)   λw.λp. 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:

(94)   For any conversational background f of type <s,<st,t>>, we define the corresponding accessibility relation R_f of type <s,st> as follows:
R_f := λw. λw'. ∀p [f(w)(p)=1 → p(w')=1].

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

Kratzer calls those conversational backgrounds that determine the set of accessible worlds *modal bases*. We can be sloppy and use this term for a number of interrelated concepts: (i) the conversational background (type <s,<st,t>>), (ii) the set of propositions assigned by the conversational background to a particular world (type <st,t>), (iii) the accessibility relation (type <s,st>) determined by (i), (iv) the set of worlds accessible from a particular world (type <s,t>).

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.

Exercise 11

Show that a conversational background f is realistic iff the corresponding accessibility relation R_f (defined as in (94)) is reflexive.

Exercise 12

Let us call an accessibility relation "trivial" if it makes every world accessible from every world. I.e., R is *trivial* iff ∀w∀w': w'∈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 13[17]

The definition in (94) specifies, in effect, a function from $D_{<s,<st,t>>}$ to $D_{<s,st>}$. It maps each function f of type <s,<st,t>> to a unique function R_f of type <s,st>.

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[17]In this exercise, we systematically substitute sets of their characteristic functions. I.e., we pretend that $D_{<s,t>}$ is the power set of W (i.e., elements of $D_{<s,t>}$ are sets of worlds), and $D_{<st,t>}$ is the power set of $D_{<s,t>}$ (i.e., elements of $D_{<st,t>}$ are sets of sets of worlds). On these assumptions, the definition in (94) can take the following form:

(i)   For any conversational background f of type <s,<st,t>>,
we define the corresponding accessibility relation R_f of type <s,st> as follows:
R_f := λw. {w': ∀p [p∈f(w) → w'∈p] }.

The last line of this can be further abbreviated to:

(ii) R_f := λw. ∩f(w)

This formulation exploits a set-theoretic notation which we have also used in condition (95) of the second part of the exercise. It is defined as follows: If S is a set of sets, then ∩S := {x: ∀Y[Y∈S → x∈Y]}.

This mapping is not one-to-one, however. Different elements of $D_{<s,<st,t>>}$ may be mapped to the same value in $D_{<s,st>}$.

- Prove this claim. I.e., give an example of two functions f and f' in $D_{<s,<st,t>>}$ for which (94) determines $R_f = R_{f'}$.

- As you have just proved, if every function of type $<s,<st,t>>$ 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 $D_{<s,<st,t>>}$ 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:

(95)   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 (94) will be one-to-one.

3.5 Attitude Verbs as Modal Operators

We now can start to formulate a neat analysis of embedding verbs like *believe, know, hope, wish*, etc. The idea is that these quantify over worlds just like the modal operators discussed so far. One distinguishing property of these "attitude verbs" is that they come with a lexically prespecified accessibility relation.

(96)   Mary believes (that) you are quiet.
        Mary believes you to be quiet.

(97)   [$_{VP}$ Mary [$_{V'}$ believe [$_{CP}$ you quiet]]]

(98)   For any w, $[\![believe]\!]^w =$.
        $\lambda p \in D_{<s,t>}.\lambda x.$[for all worlds w' compatible with what x believes in w: p(w')=1]

Exercise 14

Can you think of attitude verbs that involve existential quantification over worlds rather than universal quantification (which is what we have with *believe, know*, and *hope*) ? Can you think of attitude verbs that involve yet other kinds of quantification?

The classic paper introducing a semantics for attitude verbs as quantifying over worlds:

Hintikka, Jaako: 1969 "Semantics for Propositional Attitudes." In J.W. Davis et.al., ed., *Philosophical Logic*. Dordrecht: Reidel. 21-45.

Exercise 15: The compositional meaning of what we know

We can now fairly easily show how the intension of *what we know* is computed to be a function from evaluation worlds to sets of propositions known to be true in the evaluation world. Assume the following tree:

(99)   [$_{CP}$ what [λ_{23} [$_{VP}$ we [$_{V'}$ know p_{23}]]]]

The crucial question is what the type of the trace in the object position of *know* is. (For this question to make sense we presuppose that there is the possibility of traces of types other than e; see e.g. H&K, pp. 212f.) Make an appropriate assumption (think about what kind of object *know* is expecting) and compute the intension of the LF in (99).

It is much harder to think about what the semantics/pragmatics of the phrase *in view of what we know* has to be. We'll leave that open.

Exercise 16

Convert the intension of the LF in (99) into an accessibility relation by applying (94).

Exercise 17

Show that the intension of (99) meets the condition of "closure under entailment" that was entertained as a requirement on conversational backgrounds in Exercise 13.

4   DPs and Scope in Modal Contexts

4.1   De re vs. de dicto as a scope ambiguity

When a DP appears inside the clausal or VP complement of a modal predicate[18], there is often a so-called *de re–de dicto* ambiguity. A classic example is (100), which contains the DP *a plumber* inside the infinitive complement of *want*.

(100)   John wants to marry a plumber.

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

For example, suppose John thinks that plumbers make ideal spouses, because they can fix things around the house. He has never met one so far, but he definitely wants to marry one. In this scenario, the *de dicto* reading is true,

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

but the *de re* reading is false. What all of John's desire-worlds have in common is that they have a plumber getting married to John in them. But it's not the same plumber in all those worlds. In fact, there is no particular individual (actual plumber or other) whom he marries in every one of those worlds.

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

When confronted with this second scenario, you might, with equal justification, say 'John wants to marry a plumber', or 'John *doesn't* want to marry a plumber'. Each can be taken in a way that makes it a true description of the facts – although, of course, you cannot assert both in the same breath. This intuition fits well with the idea that we are dealing with a genuine ambiguity.[19]

Let's look at another example:

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

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

  (i) John's belief may be about an abstract that he reviewed, but since the abstract is anonymous, he doesn't know who wrote it. He told me that there was a wonderful abstract about subjacency in Hindi that is sure to be accepted. I know that it was your abstract and inform you of John's opinion by saying (101). This is the *de re* reading. In the same situation, the *de dicto* reading is false: Among John's belief worlds, there are many worlds in which *your abstract will be accepted* is not true or even false.

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

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

For all he knows, you might have written, for instance, that terrible abstract about Antecedent-Contained Deletion, which he also reviewed and is positive will be rejected.

(ii) For the other scenario, imagine that you are a famous linguist, and John doesn't have a very high opinion about the fairness of the abstract selection process. He thinks that famous people never get rejected, however the anonymous reviewers judge their submissions. He believes (correctly or incorrectly – this doesn't matter here) that you submitted a (unique) abstract. He has no specific information or opinion about the abstract's content and quality, but given his general beliefs and his knowledge that you are famous, he nevertheless believes that your abstract will be accepted. This is the *de dicto* reading. Here it is true in all of John's belief worlds that you submitted a (unique) abstract and it will be accepted. The *de re* reading of (101), though, may well be false in this scenario. Suppose – to flesh it out further – the abstract you actually submitted is that terrible one about ACD. That one surely doesn't get accepted in every one of John's belief worlds. There may be some where it gets in (unless John is certain it can't be by anyone famous, he has to allow at least the possibility that it will get in despite its low quality). But there are definitely also belief-worlds of his in which it doesn't get accepted.

We have taken care here to construct scenarios that make one of the readings true and the other false. This establishes the existence of two distinct readings. We should note, however, that there are also many possible and natural scenarios that simultaneously support the truth of *both* readings. Consider, for instance, the following third scenario for sentence (101).

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

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

In the paraphrases by which we have elucidated the two readings of our examples, we have already given away the essential idea of the analysis that we will adopt: We will treat *de dicto-de re* ambiguities as ambiguities of *scope*. The *de dicto* readings, it turns out, are the ones which we predict without further

ado if we assume that the position of the DP at LF is within the modal predicate's complement. (That is, it is either *in situ* or QRed within the complement clause.) For example:

(102)   John wants [[a plumber]$_1$ [PRO$_2$ to marry t$_1$]]

(103)   John believes$_{that}$ [the abstract-by-you will-be-accepted]

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

(104)   [a plumber]$_1$ [John wants [PRO$_2$ to marry t$_1$]]

(105)   [the abstract-by-you]$_1$ [John believes$_{that}$ [t$_1$ will-be-accepted]]

Exercise 18

Calculate the interpretations of the four structures in (102)-(105), and determine their predicted truth-values in each of the (types of) possible worlds that we described above in our introduction to the ambiguity.

Some assumptions to make the job easier: (i) Assume that (102) and (104) are evaluated with respect to a variable assignment that assigns John to the number 2. This assumption takes the place of a worked out theory of how controlled PRO is interpreted. (ii) Assume that *abstract-by-you* is an unanalyzed one-place predicate. This takes the place of a worked out theory of how genitives with a non-possessive meaning are to be analyzed.

4.2   Raised subjects

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

4.2.1   Examples of *de dicto* readings for raised subjects

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

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

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

What does (107) 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.

(108) $\exists x$ [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 (108) 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 (106). 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 (106). What you did understand me to be claiming, apparently, was not (108) but (109).

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

In other words – to use the terminology we introduced in the last section – the DP *somebody* in (106) appears to have a *de dicto* reading.

How can sentence (106) have the meaning in (109)? The LF in (107), as we saw, means something else; it expresses a *de re* reading, which typically is false when (106) 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 (106), i.e., the structure *before* the subject has raised:

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

(110) means precisely (109) (assuming that the unfilled Spec-of-IP position is semantically vacuous), as you can verify by calculating its interpretation by our rules. So is (110) (one of) the LF(s) for (106), and what assumption about syntax allow it to be generated? Or are there other – perhaps less obvious, but easier to generate – candidates for the *de dicto* LF-structure of (106)?

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

(111)   *Everyone in the class may have received an A.*
         ∃w'[w' is conforms to what I believe in w & ∀x[x is in this class in w'
         → x received an A in w']]

(112)   *At least two semanticists have to be invited.*
         ∀w'[w' conforms to what is desirable in w → there are 2 x such that x
         is a semanticist in w' & x is invited in w']]

(113)   *Somebody from New York is expected to win the lottery.*
         ∀w'[w' conforms to what is expected in w → ∃x[x is a person from NY
         in w' & x wins the lottery in w']]

(114)   *Somebody from New York is likely to win the lottery.*
         ∀w'[w' is as likely as any other world, given I know in w → ∃x[x is a
         person from NY in w' & x wins the lottery in w']][20]

(115)   *One of these two people is probably infected.*
         ∀w'[w' is as likely as any other world, given what I know in w → ∃x[x
         is one of these two people & x is in infected in w']]

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[20]Hopefully the exact analysis of the modal operators *likely* and *probably* is not too crucial for the present discussion, but you may still be wondering about it. As you see in our formula, we are thinking of *likely* (*probably*) as a kind of epistemic necessity operator, i.e., a universal quantifier over a set of worlds that is somehow determined by the speaker's knowledge. (We are focussing on the "subjective probability" sense of these words. Perhaps there is 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.

To bring out the intended *de dicto* reading of the last example (to pick just one) imagine this scenario: We are tracking a dangerous virus infection and have sampled blood from two particular patients. Unfortunately, we were sloppy and the blood samples ended up all mixed up in one container. The virus count is high enough to make it quite probable that one of the patients is infected but because of the mix-up we have no evidence about which one of them it may be. In this scenario, (115) appears to be true. It would not be true under a *de re* reading, because neither one of the two people is infected in every one of the likely worlds.

A word of clarification about our empirical claim: We have been concentrating on the observation that *de dicto* readings are *available*, but have not addressed the question whether they are the *only* available readings or coexist with equally possible *de re* readings. Indeed, some of the sentences in our list appear to be ambiguous: For example, it seems that (113) could also be understood to claim that there is a particular New Yorker who is likely to win (e.g., because he has bribed everybody). Others arguably are not ambiguous and can only be read *de dicto*. This is what v. Fintel & Iatridou claim about sentences like (111). They note that if (111) also allowed a *de re* reading, it should be possible to make coherent sense of (116).

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

In fact, (116) sounds contradictory, which they show is explained if only the *de dicto* reading is permitted by the grammar. They conjecture that this is a systematic property of epistemic modal operators (as opposed to deontic and other types of modalities). Epistemic operators always have widest scope in their sentence.

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

To complicate the empirical picture further, there are also examples where raised subjects are unambiguously *de re*. Such cases have been around in the syntactic literature for a while, and they have recently received renewed attention in the work of Lasnik and others. See Iatridou (2002)[21] for a comprehensive survey and interesting new data and generalizations. 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.

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

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[21] "What I've learned about reconstruction in A-chains," handout from "More Advanced Syntax" class, ms. MIT

(117) does not have a *de dicto* reading parallel to the one for (114) above, i.e., it cannot mean that it is likely that nobody from NY will win. It can only mean that there is nobody from NY who is likely to win. This too is an issue that we set aside.

In the next couple of sections, all that we are trying to do is find and justify a mechanism by which the grammar is capable to generate both *de re* and *de dicto* readings for subjects that have raised over modal operators. It is quite conceivable, of course, that the nature of the additional constraints which often exclude one reading or the other is ultimately relevant to this discussion and that a better understanding of them may undermine our conclusions. But this is something we must leave for further research.

4.2.2   Syntactic "Reconstruction"

Given that the *de dicto* reading of (106) we are aiming to generate is equivalent to the formula in (109), an obvious idea is that there is an LF which is essentially the pre-movement structure of this sentence, i.e., the structure prior to the raising of the subject above the operator. There are a number of ways to make such an LF available.

One option, most recently defended in Elbourne & Sauerland, 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 *de dicto* reading.

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

Yet another solution was first proposed by May (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.

(118) 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 (118) interpretable, at least not within our framework of assumptions, for (119) is still not a candidate for an actual reading of (106).

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

We would need to assume further that the topmost binder index could be deleted along with the unbound trace, and also that the indices i and j can be the same, so that the raising trace t_j is bound by the binding-index created by QR. If these things can be properly worked out somehow, then this is another way to generate the *de dicto* reading. Notice that the LF is not exactly the same as on

the previous two approaches, since the subject ends up in an adjoined position rather than in its original argument position, but this difference is obviously without semantic import.

What all of these approaches have in common is that they place the burden of generating the *de dicto* reading for raised subjects on the syntactic derivation. Somehow or other, they all wind up with structures in which the subject is lower than it is on the surface and thereby falls within the scope of the modal operator. They also have in common that they take the modal operator (here the auxiliary, in other cases a main predicate or an adverb) to be staying put. I.e., they assume that the *de dicto* readings are not due to the modal operator being covertly higher than it seems to be, but to the subject being lower. Approaches with these features will be said to appeal to "syntactic reconstruction" of the subject.[22]

4.2.3   Some alternatives to syntactic reconstruction

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

1. Raising the modal operator, variant 1: no trace

Conceivably, an LF for the *de dicto* reading of (106) might be derived from the S-structure (=(107)) 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. <st,t>). If it had that type, however, the movement would be semantically inconsequential, i.e., the structure would mean exactly the same as (107). So this would not be a way to provide an LF for the *de dicto* reading. If there was no trace left however (and also no binder index introduced), we indeed would obtain the *de dicto* reading.

Exercise 19

Prove the claims we just made in the previous paragraph. Why is no type for the trace other than <st,t> 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?

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[22] 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.

2. Raising the modal operator, variant 2: trace of type s

[Requires slightly modified inventory of composition rules. Derives an interpretation that is not quite the same as the *de dicto* reading we have assumed so far. Rather, it is a "narrow-Q, R-de-re" interpretation in the sense of Section 6 below.]

3. Higher type for trace of raising, variant 1: type <et,t>

[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. (107), gives us the *de re* reading. This, however, is correct only on the tacit assumption that the trace of raising is a variable of type e. If it is part of our general theory that all variables, or at least all interpretable binder indices (hence all bound variables), in our LFs are of type e, then there is nothing more here to say. But it is not *prima facie* obvious that we must or should make this general assumption, and if we don't, then the tree in (107) 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 <et,t>:

(120)   somebody $\lambda_{2,<et,t>}$ [[must R] [$t_{2,<et,t>}$ have-been-here]]

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

Exercise 20

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. (121) contains a universal quantifier and a negation, and it is scopally ambiguous between the readings in (a) and (b).

(121)   Everything that glitters is not gold.
        a. $\forall x$[x glitters $\rightarrow \neg$ x is gold] "surface scope"
        b. $\neg\forall x$[x glitters $\rightarrow$ x is gold] "inverse scope"

We could derive the inverse scope reading for (121) 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 <<e,t>,t>.

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

Exercise 21

Convince yourself that there are no other types for the raising trace besides e and <et,t> that would make the structure in (107) interpretable. (At least not if we stick exactly to our current composition rules.)

4. Higher type for trace of raising, variant 2: type <s,<et,t>>

If we want to get *exactly* the *de dicto* reading that results from syntactic recon-
struction out of a surface-like LF of the form (107), we must use an even higher
type for the raising trace, namely <s,<<e,t>,t>>, 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 <s,<<e,t>,t>> and its sister is
of type <e,t>. These two connot combine by either FA or IFA, but it works if
we employ another variant of functional application.[23]

(122)   *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 22

Calculate the truth-conditions of (107) under the assumption that the trace of
the subject quantifier is of type <s,<<e,t>,t>>.

4.2.4   Can we choose between all these options?

Two of the methods we tried derived readings in which the raised subject's
quantificational determiner took scope below the world-quantifier in the modal
operator, but the raised subject's *restricting NP* still was evaluated in the ut-
terance 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 sub-
jects besides their wide-scope readings. In other words, even if we allowed one
of the mechanisms that generated these sort of hybrid readings, we would still
need another mechanism that gives us, for at least some examples, the "real"
de dicto readings that we obtain e.g. by syntactic reconstruction. The relevant
examples that show this most clearly involve DPs with more descriptive content
than *somebody* and whose NPs express clearly contingent properties.

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

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[23]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 <s,t>, 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
$[\![\beta]\!]^w$ to $[\![\gamma]\!]^w$(w). At most one of them will be applicable to each given branching node,
depending on the type of $[\![\gamma]\!]^w$.

If I say this instead of our original (106) 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 (123), however, that if Bill isn't a neat-freak, then it wasn't him in my office. I.e., (123) *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 (123) expresses the "genuine" *de dicto* reading in (124), but not if it expresses the "hybrid" reading in (125).

(124) $\forall$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']]

(125) $\forall$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 (124).

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.

(126)   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 <s,<et,t>> 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.

Lebeaux, David: 1994 "Where does Binding Theory apply?" Univ. of Maryland ms.

Heycock, Caroline: 1995 "Asymmetries in Reconstruction," *Linguistic Inquiry* 26.4, pp. 547 - 570.

Romero, Maribel: 1997 "The Correlation between Scope Reconstruction and Connectivity Effects," in WCCFL 16

Fox, Danny: 1999 "Reconstruction, Binding Theory, and the Interpretation of Chains," *Linguistic Inquiry* 30, pp. 157 - 196.

Fox, Danny: 2000 *Economy and Semantic Interpretation*, Cambridge: MIT Press [especially ch. 5]

Sternefeld, Wolfgang: 1997 "The Semantics of Reconstruction and Connectivity," University of Tübingen, SFB 340 working paper

Sharvit, Yael: 1998 "Possessive Wh-Expressions and Reconstruction," in NELS 28

Scope reconstruction and Condition C: an example from Fox (1999) (building on Lebeaux 1994 and Heycock 1995):

(127)   a.   A student of his$_1$ seems to David$_1$ to be at the party.
              ^{OK}*de re*, ^{OK}*de dicto*

         b.   A student of David's$_1$ seems to him$_1$ to be at the party.
              ^{OK}*de re*, *de dicto

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

Raising of idiom chunks:

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

(129)   <> Advantage might have been taken of them.

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

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

4.3   Anaphoric pronouns in modal contexts

[24]

Let us begin with another example that displays the by now familar *de re-de dicto* ambiguity involving a modal verb and a DP in its complement.

(130)   I have to return *one of these books.*

This can mean that there is one among these books which I return in every world in which I fulfill my obligations (*de re*), and it can mean that in every world in which I fulfill my obligations, I return (a possibly different) one of these books (*de dicto*). Interestingly, only one of these two readings – namely the *de re* reading – is available when we embed (130) in a text like (131), which has an anaphoric pronoun in the subsequent sentence.

(131)   I have to return one of these books. But I am not finished with *it.*

Similar disambiguating effects are observed in (132) and (133). By themselves, the first sentences in (132) and (133) are ambiguous between *de re* readings and *de dicto* readings. But only the *de re* readings seem to be consistent with the anaphoric continuations.

(132)   Two candidates could get hired. They aren't very optimistic, though.

(133)   Jane wants to marry a plumber. He owns a house.

What explains these judgments?

Recall standard assumptions about pronouns. Setting aside, for the time being, the existence of E-Type pronouns (but we will return to this shortly), a pronoun is a variable (of type e). It can be a bound variable or a free variable, and in the latter case it must receive a salient referent from the utterance context. The pronoun in the second sentence of (131) is not in the right environment to be a bound variable, so it has to be analyzed as free. This implies that it refers to an individual, and that this individual is appropriately salient at the point when the pronoun is processed. Since we did not provide any extralinguistic context, it appears to be the utterance of the first sentence in (131) which is responsible for making salient the intended referent of *it.* How does this work?

Well, if the first sentence in (131) is read *de re*, then it asserts that there is one among these books which the speaker has to return. When the hearer accepts the truth of this assertion (and moreover guesses that there is no more than one such book), then the book which the speaker has to return will be salient to her. So this book is a natural candidate for the reference of the *it*, and she will spontaneously understand the second sentence as claiming that the speaker is not yet finished with the book he has to return. This indeed is how the text in (131) appears to be understood.

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[24]Before you study this section, please review H&K ch. 11 "E-Type Anaphora."

We have shown, then, that a *de re* disambiguation of the first sentence of (131) provides an appropriate context for the processing of the second sentence with the pronoun in it. So we have explained why a *de re* reading is available here; but we have not yet explained why a *de dicto* reading is not. To account for the latter fact, we must argue that the *de dicto* reading is not suitable for singling out a referent for the pronoun. Consider what the *de dicto* reading asserts: it says that in each of the worlds in which the speaker fulfills his obligations, he returns one of these books. In some of those accessible worlds, he returns book A, in others he returns book B, in yet others he returns book C. (Suppose that the plurality referred to by *these books* consists of just A, B, and C.) There is then no one book among these three that is especially singled out as the one that supports the truth of the *de dicto* assertion. Therefore, we submit, the use of the free pronoun *it* is not felicitous when it follows the *de dicto* assertion. Since the hearer takes for granted that the text as a whole is a felicitous utterance, she spontaneously disambiguates the first sentence in favor of its *de re* reading.

The general prediction which emerges from this discussion is the following: When a DP in the complement of a modal operator is intended as the antecedent of a pronoun outside that operator's scope, then this DP must be read *de re* – more precisely, it must be construed with scope over the modal operator. The situation is exactly analogous when we look at examples which involve an ordinary quantifier over individuals instead of the modal operator. Compare (131) to (134).

(134)   One of the reviewers has read every abstract. I have talked to her.

In isolation, the first sentence of (134) is scopally ambiguous, and permits, in particular, a reading which is true if different abstracts are read by different reviewers. But this reading is not available with the continuation in (134). The need to identify a salient referent for the pronoun *her* forces us to read the preceding sentence with wide scope for the subject. By adopting a quantificational approach to modal predicates and a scopal account of *de re-de dicto* ambiguities, we are led to perceive the semantic structures of (134) and (131) as completely parallel and to expect analogous disambiguating effects from the presence of a referential anaphoric pronoun. And this is just what we have found.

A closer look at the data reveals that an anaphoric pronoun does not always force a *de re* reading of its antecedent. Consider the following variants of (131), (132), and (133).

(135)   I have to return one of these books. I am supposed to drop it off tomorrow.

(136)   Two candidates could get hired. They could get half-time positions.

(137)   Jane wants to marry a plumber. He has to own a house.

In these examples, *de dicto* readings of indefinite DPs in the initial sentences are intuitively available, even when the pronouns take these DPs as antecedents. How come? One difference between these examples and the ones in (131)-(133)

is that here we have another modal operator in the second sentence (the sentence containing the pronoun). We will see that this is significant.

The account that we will propose for the availability of *de dicto* readings in (135)-(137) is an application (or extension) of the E-Type analysis of pronouns discussed in ch. 11 of H&K. The informal idea behind the E-Type analysis, as you recall, was that certain pronouns are interpreted as if they were definite descriptions that contain a bound variable. For the pronouns in (135)-(137), we will propose, in a nutshell, that they are like definite descriptions which contain a bound *world* variable. To see the idea, consider the following rendition of the truth-conditions of (135).

(138)   For every accessible world w: in w, I return one of these books. And moreover, for every accessible world w: in w, I drop *the book I return in w* off tomorrow.

The underlined definite in (138) corresponds to the pronoun *it* in (135). It picks out a unique book for each (accessible) world w, but not necessarily the same book in different worlds. Suppose again that *these books* refers to the plurality comprising books A, B, and C. In the first sentence of (135), read *de dicto*, I claim that every world in which I fulfill my obligations is a world in which I return A, B, or C. In some of these worlds I return A, in others B, in yet others C. The second sentence of (135) quantifies over the same set of worlds: *supposed-to* here also ranges over the worlds in which I fulfill my obligations. The *supposed-to* sentence now says that in each such world, I drop off tomorrow the book that I return in that world. So in those worlds where I return A, I drop A off tomorrow; in those where I return B, I drop B off tomorrow; and in those worlds where I return C, I drop C off tomorrow. Indeed, these seem to be the truth-conditions which we actually get for (135) when we read the first sentence *de dicto* and the second with the *it* anaphoric to *one of these books*.

The technical implementation of this account is a straightforward combination of the material from chapter 11 with our current treatment of modal predicates. Recall that in ch. 11 we decided to represent E-Type pronouns at LF as consisting of a covert definite article followed by a predicate made up of two variables: a free relation-variable (type <e,et>) and a bound pronoun of type e. In the cases that we are considering here now, the bound "pronoun" should be of type s (taking worlds as values) and the free relation-variable correspondingly of type <s,et>.

Suppose then that the LF of the second sentence of (135) looks like this:

(139)   [w-PRO λ_2 [[supposed $t_{s,2}$] R [w-PRO λ_1 I [drop-off-tomorrow $t_{s,1}$ [the [$r_{<s,et>}$ w-pro$_1$]]]]]]

The subtree representing the pronoun *it* here contains the definite article *the* and a free variable r of type <s,et>. r must receive a value from the context, and for the intended reading of the example, we assume that its value is the function which maps each world w to the set of books that I return in w.[25]

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[25]Notice that this function is defined for all possible worlds, not just those which are

(We take it that this function has become salient to the hearer as a result of processing the first sentence of (135).) Since, r requires as its first argument a world, we generate a world-pronominal as its sister. This pronominal can be coindexed with the abstractor over worlds introduced by the movement of the vacuous w-PRO in the world-argument position of the verb *drop off*.

In this section, we have tried to show that the scopal treatment of *de re-de dicto* ambiguities interacts with an independently motivated theory of pronoun interpretation, and to confirm at least some of the resulting empirical predictions about the interpretations of anaphoric pronouns and their antecedents in modalized sentences. Of course, we have only considered a very small set of data, and the full picture of the facts is more complicated.

Partee, Barbara: 1970 "Opacity, Coreference, and Pronouns," *Synthese* 21, pp. 359 - 85.

Roberts, Craige: 1989 "Modal Subordination and Pronominal Anaphora in Discourse," *L&P* 12.6, pp. 683 - 721.

Poesio, Massimo & Sandro Zucchi: 1992 "On Telescoping," *SALT* 2, pp.

Exercise 23

Discuss the following passage from Montague's famous paper "The Proper Treatment of Quantification in Ordinary English" (PTQ):

Montague, Richard: 1973 "The Proper Treatment of Quantification in Ordinary English," in J. Hintikka, J. Moravcsik, and P. Suppes (eds.) *Approaches to Natural Language: Proceedings of the 1970 Stanford Workshop on Grammar and Semantics*, Dordrecht: Reidel, pp. 221 - 242. [Reprinted in R. Thomason (ed.) *Formal Philosophy: Selected Papers of Richard Montague*, New Haven: Yale University Press, 1974, pp. 247 - 270.]

> . . . The next example indicates the necessity of allowing verb phrases as well as sentences to be conjoined and quantified. Without such provisions the sentence *John wishes to find a unicorn and eat it* would (unacceptably, as several linguists have pointed out in connection with parallel examples) have only a "referential" reading, that is, one that entails that there are unicorns. [. . .] The next example is somewhat simpler, in that it does not involve conjoining or quantifying verb phrases; but it also illustrates the possibility of a nonreferential reading in the presence of a pronoun.
>
> *Mary believes that John finds a unicorn and he eats it*
>
> [. . .]
>
> On the other hand, in each of the following examples only one reading is possible, and that [is] the referential:

---

accessible under (the intended value for) R, i.e. those where I fulfill my obligations. It is therefore not guaranteed that when applied to an arbitrary argument, this function will pick out a singleton set containing at least and at most one book. However, if we take the first sentence of (135) to be true (i.e., we take it to be true that in each R-accessible world I return one of A, B, C), and if moreover we disregard any R-accessible worlds in which I return more than one book, then we can be sure that r picks out a set of exactly one book in every R-accessible world (under consideration).

(140)   John seeks a unicorn and Mary seeks it

(141)   John tries to find a unicorn and wishes to eat it

[...]

This is, according to my intuitions (and, if I guess correctly from remarks in Partee [1970], those of Barbara Partee as well), as it should be; but David Kaplan would differ, at least as to (141). Let him, however, and those who might sympathize with him consider the following variant of (141) and attempt to make nonreferential sense of it:

(142)   John wishes to find a unicorn and tries to eat it

There are (at least) two points worth scrutinizing here: First, Montague assumes that his first example (*John wishes to find a unicorn and eat it*) is appropriately treated by giving *a unicorn* scope over the coordinate VP and letting it bind *it* as an ordinary bound variable pronoun. This assumption might be problematic in light of analogous examples such as *John wants to buy just one bottle of wine and serve it with the main course.*

Second, there is the claim that (141) has only a "referential" reading, qualified by a reference to diverging judgments. (Partee 1970, incidentally, seems to side with Kaplan's rather than Montague's judgment; see her remark on her example (52), p. 373: *John was trying to catch a fish. He wanted to eat it for supper.*) What is interesting here is that Montague switches to (142) to obtain a clearer judgment. He seems to assume that any reasonable theory that predicted a "nonreferential" reading for (141) would have to do the same for (142). Is this assumption justified? In particular, if the "nonreferential" reading of (141) were to be given an E-Type analysis, might it be feasible to spell out the semantics of *wish* and *try* in such a way that an analogous reading would not automatically arise for (142)?

5   Modal predicates and argument structure

The modal operators we have considered so far have been of two semantic types: (i) type <st,t>, which we assumed for modal auxiliaries, main modal verbs like *need to*, *have to*, and adjectives like *likely*[26],[27]; and (ii) type <st,et>, the type of attitude verbs like *believe* and *want*. The syntactic properties of the lexical items of each of these semantic types are diverse:

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[26] In this section, we concentrate on modal operators that are syntactic heads, i.e. verbs (and adjectives). We will completely disregard adverbs (like 'possibly', 'necessarily').

[27] Actually, our type for the modals themselves is not <st,t>, but rather <<s,st>,<st,t>>. <st,t> is really the type of the constituent which already includes the modal *and its covert restrictor*. In this section, we will consistently talk as if the covert restrictors were already included in the lexical items which require them. So strictly speaking, when we talk about the type of a modal verb, we really mean the type of the node dominating the verb and the R-variable.

(143)   for semantic type <st,et>:

   a.   verbs (adjectives) with *that*-clause and *for*-clause complements:
        V, subcategorizes for CP with *that* or *for believe (that), say, prefer (for),...(aware, eager,...)*

   b.   exceptional case-marking (ECM) verbs:
        V, subcategorizes for IP
        believe,...

(144)   for semantic type <st,t>:

   a.   modal auxiliaries:
        Infl, subcategorizes for VP
        must, may,...
   b.   raising verbs (and adjectives):
        V(or A), subcategorizes for IP
        have (to), need (to),...(likely (to),...)
   c.   verbs (and adjectives) with expletive subjects:
        V (or A), subcategorizes for CP with *that* or *for*
        seem,...(possible,...)

In groups (144b) and (144c) we can also include the passives (without by-phrase) of verbs in (143b) and (143a). (E.g. *There are allowed to be cars on the beach; It is known that....*). The syntactic concepts used in this classification are open to revision, of course. Also the list is not meant to be exhaustive.

What additional semantic types do we find in lexical items that create intensional contexts? If we consider verbs like *tell* (in *John told Mary that...*), we presumably need a type with a second type-e argument, i.e. <st,<e,et>>. What about the type of the intensional argument; does this always have to be a proposition (<s,t>)? In particular, could it also be <s,et>, i.e. a 1-place property? What might be examples (or candidates for examples) of predicates whose extensions are of, say, types <<s,et>,t>, <<s,et>,et>, or <<s,et>,<e,et>>?

If we were not assuming the VP-internal subject hypothesis, then our first guess about the semantic type of modal auxiliaries would probably have been <<s,et>,et>. This would be the type to make them straightforwardly interpretable in syntactic structures like (145).

(145)   [$_{IP}$ John [$_{I'}$ [must R] [$_{VP}$ leave]]]

Even if we do stick to the VP-internal subject hypothesis, however, the raising analysis of modals that we have so far taken for granted is not our only option. The subject internal to the VP could conceivably be a PRO, as in (146).

(146)   [$_{IP}$ John [$_{I'}$ [must R] [$_{VP}$ PRO leave]]]

If PRO is treated as we suggested in H&K, ch. 8, i.e., as *semantically vacuous* (though it may sometimes move and then leave a non-vacuous trace), then (146)

is exactly the same as (145) in its implications for the semantic type of *must-R*. And if a vacuous PRO is also an option for the subject-positions of certain kinds of IPs or CPs, then there also are many *prima facie* candidates for main verbs (and adjectives) whose semantic types would start with <s,et> rather than <s,t>.

When we adopted the raising analysis of modal auxiliaries (and verbs like *have to*, *need to*), we did so without explicit motivation and discussion of alternatives. In this section, we are trying to fill this gap. We will compare the empirical predictions of the raising analysis (type <st,t>) with the predictions of several different kinds of non-raising analyses. We will find that the behavior of the modal auxiliaries and of many modal main verbs (including *have to* and *need to*) is indeed accounted for more successfully by the raising analysis than by any of those alternatives. We will also ask whether *any* lexical items in natural languages behave as predicted by these alternative analyses, and we will conclude with some speculations about universal constraints on possible lexical items.

5.1   A type-<<s,et>,et> analysis for modals

Suppose we adopted a syntactic representation as in (145) or (146). Here the modal (including its restrictor) combines first with a complement whose intension is a 1-place property, and then with an external argument which denotes an individual. A natural guess, therefore, is that the denotation of the modal+restrictor should be of type <<s,et>,et>, and hence the denotation of the modal by itself of type <<s,st>,<<s,et>,et>>. Can we write suitable lexical entries with this type? Here is a proposal.

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

    a. $[\![must]\!]^w = \lambda R_{<s,st>}.\lambda P_{<s,et>}.\lambda x_e.\ \forall w'\ [w' \in R(w) \rightarrow P(w')(x) = 1]$

    b. $[\![may]\!]^w = \lambda R_{<s,st>}.\lambda P_{<s,et>}.\lambda x_e.\ w'\ [w' \in R(w)\ \&\ P(w')(x) = 1]$

So for the modal+restrictor node, we will have (148). Compare this with (149), which is what we had for the same node on the raising analysis.

(148) $[\![must]\!]^{w,[\mathbf{R} \rightarrow R]} = \lambda P_{<s,et>}.\lambda x_e.\forall w'\ [w' \in R(w) \rightarrow P(w')(x) = 1]$ $(=: G)$

(149) $[\![must]\!]^{w,[\mathbf{R} \rightarrow R]} = \lambda p_{<s,t>}.\forall w'\ [w' \in R(w) \rightarrow p(w') = 1]$ $(=: F)$

The function defined in (149)– let's call it F – takes a proposition; the function defined in (148), G, instead takes first a property and then an individual. Apart from this difference, these two functions perform similar jobs, as we can see when we define one in terms of the other:

(150) $G = \lambda P_{<s,et>}.\ \lambda x_e.\ F(\lambda w.P(w)(x))$

(150) is a recipe for constructing G, given F. What (150) says intuitively is this: if you want to know what value G yields when applied to P and x, construct the proposition that x has property P, and then apply F to that proposition.

Given that the new type-$\langle\langle s,et\rangle,et\rangle$ meaning of the modal is constructed in this way from the old type-$\langle st,t\rangle$ meaning, the predicted truth-conditions for the new structures in (145)/(146) will be systematically the same as for the old raising structures. In the raising analysis, *John* and *leave* formed a syntactic unit[28], therefore the composition rule applying to this unit determined that we should calculate the proposition that John leaves. The modal then applied to that proposition. In the new analysis, *John* and *leave* are separate pieces, so we don't know from the composition rules alone that we should put them together into the proposition that John leaves. But the new lexical entry of the modal, which takes both of these pieces as arguments, has it written into it that we are supposed to construct this proposition. The division of labor between composition rules and lexical meanings is different, but the net result of the calculation is the same.

So far, our type-$\langle\langle s,et\rangle,et\rangle$ analysis seems to predict the same truth-conditions as the old raising (type-$\langle st,t\rangle$) analysis. However, we will see now that this is no longer true when we move beyond examples with referential (e.g., proper name) subjects.

Suppose the subject is a quantificational DP, as in (151).

(151)   At least one person must leave.

The syntactic structure at both S-structure and LF on the current analysis will have to be (152). (By parenthesizing the PRO, we gloss over the difference between (145) and (146).)

(152)   [$_{IP}$ [$_{DP}$ at least one person] [$_{I'}$ [$_I$ must R] [$_{VP}$ (PRO) leave]]]

This structure is interpretable by means of our new lexical entry in (148), and it expresses the *de re* reading. (*Exercise*: Verify this.) But what about the *de dicto* reading? Can we derive another LF which expresses that?

If reconstruction is the operation of deleting the upper copy (and coindexing link) of a movement chain, then of course in a non-movement structure like (152), this operation is not applicable. But the problem runs deeper than this. Even if we did allow some syntactic operation or other by which the DP *at least one person* got lowered past the modal (e.g., to substitute into the slot of the PRO, or to adjoin to the VP), that wouldn't help. It would not give us a representation of the *de dicto* reading, but only an uninterpretable structure. The sister node of *must-R* would now have a proposition as its intension (viz., the proposition $\lambda w'.\exists x[x$ is a person in w' & x leaves in w'$]$). But a proposition is not a suitable argument; as we see in (148), *must-R* needs a property. Nor would it help to allow a syntactic operation that would raise the modal above the subject. The obstacle to generating the *de dicto* reading is not in the syntax, but in the semantic type of the modal. As long as *must-R* has a denotation of type $\langle\langle s,et\rangle,et\rangle$, *de dicto* readings are predicted impossible.

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[28] We are assuming here that we have raising followed by reconstruction. Without reconstruction, the relevant syntactic unit consists of *leave* and a variable. But after the variable is bound by Predicate Abstraction and the predicate abstract is predicated of *John*, the result is the same.

It is fair to conclude, then, that our original raising analysis was superior. The existence of *de dicto* readings for subjects provides an empirical argument in its favor.

5.2   A type-<<s,et>,<<s,<et,t>>,t>> analysis for modals

We have shown that the entries in (147) cannot account for *de dicto* readings, but it would be premature to conclude that we have shown the untenability of non-raising syntactic analyses. The type that we chose above for *must-R* was indeed the simplest one to make such structures interpretable, but it was not the only possible one. Those authors who have defended non-raising analyses of modals and other paradigm "raising" predicates in the literature have also considered lexical entries like the following.[29]

(153)   For any w: $[\![must]\!]^w$
        $= \lambda R_{<s,st>}.\lambda P_{<s,et>}.\lambda Q_{<s,<et,t>>}.\ \forall w'[w' \in R(w) \rightarrow Q(w')\big(P(w')\big) = 1]$

Let's see what this entry predicts when we apply it to the LF in (152) above. What we obtain is the *de dicto* reading, even though the quantifier is syntactically higher than the modal! (*Exercise*: Verify this by doing the calculation!)

Now at first sight we have just traded one problem for another: With the new entry in (153), we capture the *de dicto* reading of sentence (151) – but what about the *de re* reading? And how do we interpret examples with proper name subjects now? (145)/(146) are uninterpretable by (153), given that *John* denotes an individual (and has an intension of type <s,e>), whereas the I'-constituent headed by the modal now calls for an argument of type <s,<et,t>>, the intension of a generalized quantifier. (And this type-mismatch cannot be remedied by additional movements. For example, if we QR the subject in (152) or (145)/(146), we will leave a trace which is also of type e and thus unsuitable as the modal's argument.[30])

If we want to be able to interpret *must*-sentences with both proper name and quantificational subjects, and to account for both *de re* and *de dicto* readings of the latter, we need to assume a type-ambiguity in some place or another.

The most elegant kind of type-shifting solution actually doesn't posit a type-ambiguity in the modal, but rather assumes that there is a type-ambiguity

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[29]It is not clear exactly who should be credited with this idea. D. Dowty ('Governed transformations as lexical rules in a Montague Grammar,' *LI* 1978) has an analogous entry for ECM ("raising-to-object") verbs, but his entry for raising-to-subject verbs is of the simpler type that we just abandoned. Maybe the earliest (published) application to modal auxiliaries and raising-to-subject verbs is in E. Klein & I. Sag (1982) "Semantic Type and Control," in M. Barlow et al. (eds.) *Developments in Generalized Phrase Structure Grammar*, Bloomington: Indiana Linguistics Club. Anyway, the idea was widely familiar by the early 1980s. See e.g. the discussion in ch. IV, sec. 9, of Chierchia's thesis (G. Chierchia, *Topics in the Syntax and Semantics of Infinitives and Gerunds*, UMass Amherst Ph.D. thesis, GLSA 1984), and in D. Dowty (1985) 'On recent analyses of the semantics of control,' *L&P* 8.

[30]*Exercise*: What happens if we move the subject in (152) and leave a trace of some other type? Which other types will yield an interpretable structure, and what interpretations will result? Is the desired *de re* reading among them?

in (non-quantificational) DPs. The idea is that any denotation of type e can be type-shifted into a denotation of type <et,t> by the following type-shifting operation known as *lift*.[31]

(154)   *lift* := $\lambda x_e.\lambda f_{<e,t>}.$ f(x)

Suppose we assume that for every lexical item α that has a denotation of type e, there is a homophonous item α' that has the interpretation in (155).

(155)   For any w, g, $[\![\alpha']\!]^{w,g} = lift([\![\alpha]\!]^{w,g})$

So, for example, in addition to the basic proper name *John*, which denotes John, there is the homophonous proper name *John'*, which denotes $\lambda f_{<e,t>}.$f(John). Suppose further that the same is true not just for lexical items (like proper names), but also for traces and pronouns (and for complex definite DPs). So for example, besides the basic trace $t_{57,}$, which – relative to a given assignment g – denotes the individual g(57), there is the "homophonous" trace t_{57}', which denotes the generalized quantifier $\lambda f_{<e,t>}.$f(g(57)).

If we combine the non-raising syntax for modals with this assumption about type-ambiguity in DPs, then we need only the entry in (153) for the modal. Here is how the analysis works:
(a) *quantificational subject with de dicto reading.* This case is most straightforward: generate LF as in (152) and interpret by (153) (no type-shifting needed).
(b) *proper name subject.* (145)/(146) is still uninterpretable, but there is now an interpretable LF which is just like these, except that it contains the type-lifted homophone *John'*:

(156) $[_{IP}$ John' $[_{I'}$ [must R] $[_{VP}$ leave]]]

Here is how (156) is interpreted:

(157) $[\![must\ R]\!]^{w,g}(\lambda w".[\![leave]\!]^{w"})(\lambda w"'.[\![John]\!]) = 1$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow [\lambda w"'.[\![John]\!]](w')([\lambda w".[\![leave]\!]^{w"}](w')) = 1\Big]$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow [\![John]\!]([\![leave]\!]^{w'}) = 1\Big]$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow lift([\![John]\!])([\![leave]\!]^{w'}) = 1\Big]$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow [\lambda f.f(John)]([\![leave]\!]^{w'}) = 1\Big]$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow [\![leave]\!]^{w'}(John) = 1\Big]$
iff
$\forall w'\Big[w'\in g(R)(w) \rightarrow John\ leaves\ in\ w'\Big]$

[31] See B. Partee (1987) "Noun Phrase Interpretation and Type-Shifting Principles," in J. Groenendijk, D. de Jongh & M. Stokhof (eds.) *Studies in Discourse Representation Theory and the Theory of Generalized Quantifiers* (GRASS 8), Foris: Dordrecht, pp. 115 - 143.

(c) *quantificational subject with de re reading.* This involves QR of the subject plus type-shifting of the QR-trace. The LF for this interpretation is (158), where t_1' is the type-shifted "homophone" of t_1. The interpretation of this structure is left as an exercise for the reader.

(158)   [$_{\text{IP}}$ at least one person λ_1 [$_{\text{IP}}$ t_1' [$_{\text{I'}}$ [must R] [$_{\text{VP}}$ leave]]]]

Exercise 24

There are other possible type-shifting analyses. For example, we could posit a type-shifting operation F that applies to modal-meanings like the one defined in (153).

(159)   F := $\lambda f_{<<s,st>,<<s,et>,<<s,<et,t>>,t>>>}$. $\lambda R<s,st>.\lambda P<s,et>.\lambda xe.$ f(R)(P)$\big(lift($

We could then posit the meaning for *must* that's defined in (153) as the basic one, and rely on (159) to give us a homonym *must'* with the denotation $[\![must']\!]^w$ = F($[\![must]\!]^w$).

- . Show that, if $[\![must]\!]^w$ is as defined in (153), then F($[\![must]\!]^w$) is exactly the denotation defined in the previous section in (147).

- . It would not be possible to take the simpler meaning in (147) as the basic one and define a type-shifting function that would map this to the more complex meaning in (153). Why not?

To summarize our findings so far, we have seen that there *is* a way to account for both *de re* and *de dicto* readings within an analysis of modals that does not involve raising of the subject from an underlying position below the modal (nor any covert lowering-operation like reconstruction), but treats the subject as a genuine argument of the modal. The price we had to pay was a rather complicated lexical type for the modal, and some type-shifting operation (affecting either the modal or the DP).

5.3   Reminder: standard test for control and raising

In introductory syntax texts, the distinction between Raising predicates and Control predicates is often motivated by a battery of "tests":

	Raising	*Control*
selectional restrictions	imposed by lower verb only	imposed by both verbs
passivization	preserves truth-conditions	changes truth-conditions
expletive subjects	okay	impossible
de dicto *subjects*	possible	impossible

See e.g. Radford (1988).[32] Here are some examples to remind you of the data that the table above is intended to summarize.

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[32]To be more accurate, only the first three of these tests are found in Radford and other books on that level. The '*de dicto* subjects' test is normally omitted, since it would be harder to explain to readers with no knowledge of semantics. But it is found in the original literature on which these textbooks draw (see for example May (1977)), and it is natural for us to include it here.

Selectional restrictions:

(160)   a.   John likes physics.
         b. #This number likes physics.
         c.   This number is divisible by 5.
         d. #John is divisible by 5.

(161)   a.   John seems to like physics.
         b. #This number seems to like physics.
         c.   This number seems to be divisible by 5.
         d. #John seems to be divisible by 5.

(162)   a.   John tries to like physics.
         b. #This number tries to like physics.
         c. #This number tries to be divisible by 5.
         d. #John tries to be divisible by 5.

Passivization:

(163)   Mary is likely to hire John.
         John is likely to be hired by Mary.
         (equivalent)

(164)   Mary is eager to hire John.
         John is eager to be hired by Mary.
         (not equivalent)

Expletives and idiom chunks:

(165)   a.   There seem to be two people in the booth.
         b.   The cat seems to be out of the bag.

(166)   a.   *There tried to be two people in the booth.
         b.   The cat tried to be out of the bag. (only non-idiomatic)

De dicto readings:

(167)   Several accomplices appeared to be involved.
         (But in reality, there weren't any accomplices.)

(168)   Several accomplices wanted to be involved.
         (#But there weren't any accomplices.)

Exercise 25

In sections 5.1 and 5.2, we have just considered two potential "non-raising" analyses of modals; one according to which the semantic type of the modal+restrictor unit was $<<s,et>,et>$ (in section 5.1), and one according to which it was $<<s,et>,<<s,$ (in section 5.2). If English (or another natural language) had modal predicates

with these kinds of entries, how would they behave with respect to the four standard diagnostics for raising that we listed above? Do you think there are actual examples of modal predicates which behave in these ways? (Consider words and phrases of all sorts of syntactic types; i.e., not just auxiliaries, but also main verbs, adjectives, etc., or syntactically complex phrases.) If you find that certain kinds of meanings are unattested (at least for simple lexical items), you may want to speculate about suitable general constraints on possible meanings that would rule them out in principle.

5.4   Expletive subjects

Among the characteristics that are standardly attributed to Raising predicates is the fact that they allow expletive subjects, such as the expletive *there* in example (169).

(169)   There must be two people in the booth.

In this section, we consider the significance of this fact for the choice among different analyses, specifically the raising analysis and the two non-raising analyses which we have spelled out above.

5.4.1   Excursion on *there-be*-sentences

Before we can talk about expletive *there* subjects in modal sentences, we need to sketch an analysis of *there*-sentences in general. So let's forget about modals for a minute and look at simpler examples like the ones below.

(170)   a.   There are two mountains visible.
    b.   There are many books on the shelf.
    c.   There are no birds sitting on the branch.

(171)   a.   There are no miracles.
    b.   There are lots of dishonest people.

The examples in (170) seem to contain a DP (type <et,t>) followed by a predicate of type <e,t>. If we assume that both *there* and *be* are semantically vacuous, the analysis of these examples is quite simple: The DP combines with the following predicate by Functional Application, and we obtain a truth-value. E.g.:

(172) $[\![there\ are\ two\ mountains\ visible]\!]^w$
    $= [\![two\ mountains]\!]^w([\![visible]\!]^w)$
    $= 1$ iff there are two x such that x is a mountain in w and x is visible in w

Notice that this analysis is independent of the choice between a number of different syntactic analyses. E.g., the predicate could be an X' and the DP its specifier (XP-internal subject). Or the predicate could be a maximal projection

and form some sort of "small clause" with the DP. Or the predicate could be adjoined to the DP, or perhaps to the VP headed by *be*. All of these options would be treated alike by our composition rules, which don't care about category labels and skip over the vacuous *be* in any case. It is also irrelevant where the vacuous *there* comes from. It could be base-generated in the Spec-of-IP position, or it could originate in the Spec of the VP headed by *be* and raise from there. (In the latter case, we would want to say that it reconstructs to Spec of VP at LF, so we don't have to worry about the uninterpretable trace and binding link that would otherwise be present.)

The examples in (171), which appear to contain only a DP besides the *there* and the *be*, are harder to deal with. The DP alone cannot give us a truth-value. Two options suggest themselves. One option is that these examples contain a silent predicate (x) in place of the overt predicates (*visible*, etc.) in (170). An appropriate lexical entry for this silent predicate would be (173).

(173) $[\![x]\!] = \lambda x.\ 1$

($\lambda x.1$ is that function of type <e,t> which maps all elements of D to the truth value 1.) The other option is that the sentences in (171) involve a homophone of *be* (or of *there*) that is not vacuous, but has the meaning in (174).[33]

(174) $[\![be]\!] = \lambda x.\ 1$

For the purposes of semantic interpretation, these two options come to the same thing. E.g., the truth-conditions of (171) are correctly predicted to be the following:

(175) $[\![\text{there are no miracles}]\!]^w$
         $= [\![\text{no miracles}]\!]^w(\lambda x.\ 1)$
         $= 1$ iff there is no x such that x is a miracle in w

5.4.2   Expletive subjects and modals

What would be the LF-structures of a sentence like (169) on the various analyses of modals that we have been considering?

On our original raising analysis, we would have an S-structure as in (176) (derived by raising *there*), from which we can obtain the LF in (177) by reconstruction.[34]

(176)   [$_{IP}$ there λ_1 [$_{I'}$ [must R] [t_1 [be [two people in the booth]]]]]

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[33] This kind of analysis is due to Barwise & Cooper (1981). For discussion of this and other common proposals for the semantics of the 'there'-construction, see Zucchi (1993) in Natural Language Semantics.

[34] Alternatively, *there* might be generated in Spec of IP to begin with, so it would never move nor have to reconstruct. The resulting LF would differ from (177) only in the location of a semantically vacuous element, so it would be the same for the purposes of interpretation. Notice that, if we do move *there* at some point in the derivation, then we have to reconstruct it to get rid of the variable and binder-index created in that movement. Otherwise, the LF would not be interpretable.

(177)   [$_{IP}$ e [$_{I'}$ [must R] [there [be [two people in the booth]]]]]

(177) is straightforwardly interpretable. Given what we said in the previous subsection about simple *there*-sentences, the constituent *there be two people in the booth* receives the interpretation in (178).

(178)   For any w,
         $[\![$*there be two people in the booth*$]\!]^w = 1$
         iff there are two x such that x is a person in w & x is in the booth in w

So we have a proposition that makes a suitable argument for the modal *must-R* on its original type-<st,t> interpretation. For the complete LF (177), we calculate (179), which accurately represents the truth-conditions of the English sentence (169).

(179)   For any w, any g:
         $[\![$*must R [there be two people in the booth]*$]\!]^{w,g} =$
         $[\![$*must R*$]\!]^{w,g}(\lambda$w'.$[\![$*two people in the booth*$]\!]^{w'}) = 1$ iff
         $\forall$w'[w'$\in$g(R)(w) $\rightarrow$ there are two x such that x is a person in w' and in the booth in w']

Consider now the implications of a non-raising analysis. The S-structure of (169) would look as in (180).

(180)   [$_{IP}$ there [$_{I'}$ [must R] [(PRO) [be [two people in the booth]]]]]

This *would* be interpretable with the old (type-<st,t>) entry for the modal, but it isn't interpretable with either one of the alternative entries that we defined in sections 5.1 and 5.2. Both of those would require the VP-node to have a 1-place property as its intension, but here it is a proposition instead.

Can we still derive an interpretable structure by means of covert movements of some kind? The only thing that would seem to help with the interpretability problem would be to move *two people* above *must-R*, but without creating a variable in the trace-position and adding a binder-index. There doesn't seem to be a way to get an interpretable structure by more standard means, i.e., by covert movement operating in the normal way. It is fair to conclude, then, that the non-raising analyses we have considered here do not extend naturally to expletive subjects, and that the raising analysis appears to have an advantage.

One way to avoid this conclusion is to call into question whether expletives really should be analyzed as semantically vacuous in the sense of having no denotation. Suppose instead that *there* does denote an element of D_e, but this is a special abstract entity (sometimes called an "ugly object"), which is stipulated to be outside the domain of every ordinary predicate extension.[35] I.e., the deviance of sentences like *there left, *there is blue, etc. is accounted for by the assumption

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[35]See e.g. Chierchia (loc. cit.; see n. 35) and earlier work cited there for attempts to spell out and defend this kind of approach. The name 'ugly object' is attributed by Chierchia to Karttunen.

that (for all w) $[\![leave]\!]^w$, $[\![blue]\!]^w$, etc. are partial functions whose domains do not include the ugly object $[\![there]\!]$. Only a few lexical items, among them the copula *be*, have lexical meanings which allow them to take the ugly object as an argument. The analysis of (simple, unmodalized) *there-be*-sentences on this approach treats neither *there* nor *be* as without denotation. While $[\![there]\!]$ denotes the ugly object which violates the selectional restrictions of all ordinary predicates, *be* now has one of the entries below, depending on the syntactic structures it is assumed to show up in.

(181) $[\![be]\!] = \lambda v_t.\lambda x_e.$ v
       for structure *[there [be [DP XP]]]*

(182) $[\![be]\!] = \lambda f_{<et,t>}.\ \lambda g_{<e,t>}.\lambda x_e.$ f(g)
       for structure *[there [[be DP] XP]]*

(183) $[\![be]\!] = \lambda f_{<et,t>}.\ \lambda x_e.$ f($\lambda y_e.1$)
       for structure *[there [be DP]]*

As you can work out for yourself, these assumptions yield correct truth-conditions for simple (unmodalized) 'there'-sentences like the ones in (170) and (171) of section 5.4.1. Moreover, they make our two non-raising analyses of modals apply straightforwardly to sentences with expletive subjects and modals. For example, the previously uninterpretable tree in (180) can now be interpreted with the entry for *must* in (147) of section 5.1, where *must-R* had type <<s,et>, et>. It can also be interpreted with the entry for *must* in (153) of section 5.2 (where *must-R* had type <<s,et>, <<s,<et,t>>, t>>), exploiting the option of type-lifting the ugly object.

Exercise 26

Carry out the appropriate calculations to verify these claims.

To sum up, we have now seen what it takes to get a non-raising analysis of modals (and other "raising" predicates) to work. In order to account for *de dicto* readings of the subject, we must let the modal denote a highly-typed function whose external argument is a generalized-quantifier intension. To cover expletive subjects, we have to commit ourselves to an 'ugly object' interpretation of expletives. These two consequences may strike us as complicated or counterintuitive, but we have not so far seen any real arguments against them.[36]

Chierchia, Gennaro: 1984 "Equi vs. Raising," ch. IV, sec. 9, of *Topics in the Syntax and Semantics of Infinitives and Gerunds*, UMass Amherst Ph.D. thesis, GLSA , pp. 368 - 381.

Jacobson, Pauline: 1990 "Raising as Function Composition," *L&P* 13.4.

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[36]If we also had considered modifying some of our more general assumptions about the syntax-semantics map, then of course this would have opened up additional possiblities. For example, we have not at all explored the option of using a greater inventory of composition principles. See Jacobson (1990; 1992) for an analysis of "raising" constructions which relies on Function Composition as a mode of semantic composition and thereby manages to reconcile a non-raising syntax with our original simple type-<st,t> semantics (and also needs no ugly objects).

Jacobson, Pauline: 1992 "Raising without Movement," in R. Larson et al. (eds.) *Control and Grammar*, Dordrecht: Kluwer, pp. 149 - 194.

Before we leave the discussion of expletives, let us mention an interesting fact which as yet remains unexplained (on any of the analyses we have been comparing). The interpretation for sentence (169) that we derived in (179) above involved a *de dicto* reading for the DP *two people*. Interestingly, this is not just one or a preferred reading for (169), but it is the only possible reading. A *de re* reading is strictly unavailable. In this respect, expletive-*there* sentences contrast with their minimally different counterparts without *there*.[37] Why should this be so? For all we know, we could derive another LF besides (177), one in which the DP *two people* has QRed to a position above the modal. This would also be interpretable (using the standard lexical entry from the raising analysis for *must*), and it would mean that there are two people who have the property that they must be in the booth – the unattested *de re* reading. (*Exercise*: Show this.) Notice that exactly the same problem arises in the non-raising analysis (with the semantic type from 5.2 and the ugly-object treatment of *there be*): there too, *two people* could raise out of the scope of the modal and leave behind a (type-lifted) trace of type e, giving rise to a *de re* reading.

As it turns out, this is part of a problem which doesn't really have to do specifically with the syntax and semantics of modal predicates (and therefore will not be discussed any further here). The general phenomenon to be explained is that the post-copular DP in expletive 'there'-sentences is always constrained to narrowest scope. For an attempt to relate this to another well-known characteristic of 'there'-sentences, the so-called Definiteness Restriction, see Heim (1987).[38]

5.5   Raising, control, and constraints on the lexicon

In the previous sections, we explored a few alternative analyses for the English modal auxiliaries. We took as given the fact that these items exhibit the empirical properties that are standardly associated with so-called "raising" verbs, and our discussion was about the success of various different analyses in accounting for those facts. We determined that one of the analyses we looked at, namely the non-raising analysis using the simpler type <<s,et>,et>-denotations, was not a viable choice. The standard raising analysis with type-<st,t>-denotations was successful, and a second viable candidate – provided that we commit to an ugly-object treatment of expletives – was the non-raising analysis with the more complicated type <<s,et>,<<s,<et,t>>,t>>-denotations. We concentrated on the example of English modal auxiliaries, but it should be clear that our findings generalize to all other words that show the same "raising"-like properties: for all of those, we now can exclude type <<s,et>,et>, but entertain either type <st,t> or (with appropriate accompanying assumptions) type <<s,et>,<<s,<et,t>>,t>>.

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[37] This may not be so clear with example (169), since a *de re* reading is kind of strange here even for the non-*there* variant *Two people must be in the booth*. A more compelling minimal pair: *Three people should have been on the committee* vs. *There should have been three people on the committee*.

[38] "Where does the Definiteness Restriction Apply? – Evidence from the Definiteness of Variables," in E. Reuland & A. ter Meulen (eds.) *The Representation of (In)definiteness*, Cambridge: MIT Press.

In this section, we turn our attention to a different question. We will no longer be concerned just with finding the right analysis to predict the behavior of a given set of lexical items. Rather we will aim to make some predictions about the range of possible lexical items allowed by Universal Grammar. So, for example, we will look again at the already discarded type-$\langle\langle s,et\rangle,et\rangle$ entry for *must* and will ask ourselves a new question: Granted that this isn't the meaning of *must* – could it still be the meaning of *some* verb or adjective, in English or in some other natural language? Are there any words out there that do behave in precisely the way that *must* would have had to for us to maintain this entry for it? And if not, then why not?

Suppose there were an English verb *xxx* with just the lexical entry we entertained in section 5.1 for *must*, repeated here:

(184)　$[\![xxx]\!]^{w,[\mathbf{R}\rightarrow R]} = \lambda P_{\langle s,et\rangle}.\ \lambda x_e.\ \forall w'\ [w' \in R(w) \rightarrow P(w')(x) = 1]$

How would this verb behave in regard to the "tests" that are commonly employed to distinguish so-called "raising" verbs from so-called "control" verbs? Well, as we already saw in section 5.1, it would never allow *de dicto* readings for its subject, and in this respect it would look like a "control" verb. What about some other tests?

Another characteristic of "control" verbs is that active-passive pairs like the one in (185) are truth-conditionally non-equivalent (in contrast with analogous pairs with "raising" predicates like (186), which are always equivalent).

(185)　a.　Doctor Smith hopes to examine John.
　　　　b.　John hopes to be examined by doctor Smith.

(186)　a.　Doctor Smith is likely to examine John.
　　　　b.　John is likely to be examined by doctor Smith.

How will our hypothetical verb *xxx* behave in this regard? The two LFs for the active-passive pair will look as follows:[39]

(187)　[Dr Smith [xxx [PRO [examine John]]]]

(188)　[John [xxx [PRO λ_1 [(be) [[examined t_1] [(by) Dr Smith]]]]]]

Calculating the interpretation up to the step that depends on the lexical entry for *xxx*, we know that (187) is true in w iff $[\![xxx]\!]^{w,[\mathbf{R}\rightarrow R]}(\lambda w'.\lambda x.\ x$ examines

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[39]We are assuming a movement analysis of the passive here, on which the passive morphology is semantically vacuous. An alternative would be a lexical analysis, which treats the passive morpheme as a relation-changing operation ($\lambda f_{\langle e,et\rangle}.\lambda x.\lambda y.f(y)(x)$) and base-generates the two argument DPs in their surface hierarchical order. This would not make any difference to the discussion in this section.

Notice, by the way, that if we did not have a PRO-subject in the complement of *xxx* (but no subject at all, not even a semantically vacuous one), then the movement analysis would be unavailable to us here and we would be forced to choose the lexical analysis of passives This is the reason why many authors conclude that a non-raising analysis of "raising" verbs is incompatible with a movement analysis of passive. The conclusion may hold on their assumptions, but not in the context of the H&K treatment of PRO (where PRO itself is vacuous, but capable of leaving a non-vacuous trace when moving).

John in w')(Smith) = 1, and that (188) is true in w iff $[\![xxx]\!]^{w,[\mathbf{R}\to R]}(\lambda w'.\lambda x.$ Smith examines x in w')(John) = 1. Given the entry for *xxx* in (1), and given that, for all w', [λx. x examines John in w'](Smith) = [λx. Smith examines x in w'](John), it follows that $[\![(187)]\!]^{w,[\mathbf{R}\to R]} = [\![(188)]\!]^{w,[\mathbf{R}\to R]}$. So the truth-conditions of the two structures (in a given utterance context) are identical. In the passive test, then, our hypothetical verb *xxx* is predicted to act like a "raising" verb.

A caveat is in order here: The prediction that (187) and (188) are equivalent means only that their truth-conditions will coincide if they are evaluated w.r.t. to the same contextually supplied accessibility relation. If (187) were used in a context which supplies one accessibility relation R_1, and (188) in a context which supplies a different one, R_2, then of course they could well differ in truth-value. For example, it may happen that the active sentence (187) is uttered with the tacit understanding that we are quantifying over those possible worlds in which *Dr Smith* fulfills his duties, and that the passive sentence (188) is uttered with the understanding that we are talking about those worlds in which *John* fulfills his duties. Then these two utterances will express different propositions, and maybe one of them is true and the other false.

This implies that we will have to be very careful when we evaluate speaker's judgments as to whether a given verb does or doesn't pass the equivalence-under-passivization test. If there is (suspected) context-dependency of the accessibility relation, we'll have to make sure that people are really resolving it in the same way for the two sentences. If we just present the sentences out of context, this should not be taken for granted. People will then have to exercise their imagination to fill in a natural context, and in doing so they may well be influenced in a roundabout way by the very fact that one sentence is in the active voice and the other one in the passive. Passivization, even though it doesn't affect truth-conditions (in simple sentences), does have some effect on non-truth-conditional aspects of meaning or discourse-coherence. These effects are not well understood, but there is, speaking very roughly and vaguely, a *ceteris paribus* tendency for the surface subject to denote the topic of the discourse. This might indirectly affect the relative salience of different competing candidates for the accessibility relation. In other words, if Dr Smith is referred to with the subject of the sentence, and therefore is perceived as the discourse topic, then the accessibility relation which is defined in terms of Dr Smith's duties is *ceteris paribus* more salient then the one defined in terms of John's duties. So a verb with the semantics defined in (184) may *appear* to fail the equivalence-under-passivization test, due to an indirect chain of connections between the discourse function of passivization and the strategies for the resolution of context-dependence. (And, for the same reason, even a verb with the simpler type <st,t> entry that is our official proposal for *must-R* may appear to fail it!)

However, even if this effect is quite strong and systematic, we can still tell the difference between a verb like *xxx*, which guarantees equivalence under passivization in a fixed context, and a verb whose meaning is defined in such a way that it "hard-wires" a distinctive contribution of the subject to the truth-conditions. The difference will be that we can, in principle, give independent contextual clues about the intended accessibility relation and thereby counteract and over-

ride the effect of the active/passive choice.[40]

Let us return now to the main thread of our discussion. What do we learn from our investigation of the predicted behavior of our hypothetical verb *xxx* w.r.t. to standard diagnostics for "control" and "raising"? We could continue to proceed through the whole list of tests, but already we have seen enough to conclude that *xxx* displays a mixed pattern of behavior w.r.t. these standard diagnostics: On at least one test (availability of *de dicto* readings), it acts "control"-like, and on at least one other one (equivalence under passivization), it acts "raising"-like. This is interesting, because it makes *xxx* a counterexample to an assumption which is widely shared (though often left implicit) in the syntactic literature, namely the assumption that the characteristics targeted by the standard tests "cluster together"; in other words, any given lexical item will either act "raising"-like on all test, or else act "control"-like on all tests.[41] Let us call this the "Clustering Assumption". More precisely, *xxx* is relevant to this assumption in the following way: First of all, the very fact that we were able to write down an explicit and coherent lexical entry like the one for *xxx* in (184) shows that the Clustering Assumption is not conceptually necessary, but rather constitutes a substantive empirical generalization. Given this, we now are motivated to look for *real* counterexamples in the vocabularies of the world's languages, and the hypothetical example of *xxx* gives us some concrete idea of what we should be looking for. And if this search turns out to be unsuccessful (i.e., we don't find real counterexamples), then the example of *xxx* will give us some guidance in our endeavor to identify the principle(s) of Universal Grammar from which the Clustering Assumption follows.

Let us skip here over the survey of known data and the many non-trivial problems in the interpretation of that data, and let us proceed on the assumption that the Clustering Assumption is empirically correct. This means that *xxx*, as interpreted in (184) above, is not a possible word in natural language. Why not? Could it be that there are *no* lexical meanings of this semantic type at all? That is *prima facie* implausible, since type $<<s,et>,et>$ appears to be just the type we need to treat genuine subject-control verbs like *try*.[42] So let's assume that there is nothing wrong with the semantic type of *xxx* in entry (184) *per*

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[40] See Bhatt 1998 (Rajesh Bhatt, "Obligation and Possession," in H. Harley (ed.) MITWPL 32: *Papers from the UPenn/MIT Roundtable on Argument Structure and Aspect*, pp. 21 - 40. [esp. section 4]) for related discussion. Giving proper attention to the complexities of strategies for the resolution of context-dependence may also help us make some sense of the inconclusive evidence presented by Jackendoff (1972; pp. 104f.). See also Brennan 1993 (Virginia Brennan, *Root and Epistemic Modal Auxiliary Verbs*. Ph.D. Dissertation, University of Massachusetts at Amherst. [Chapters 1 and 2 on the argument structure of various kinds of modal auxiliaries]).

[41] This is not meant to exclude the possibility that a given word may be *ambiguous* between raising and control meanings. (Many authors in fact have posited pervasive systematic ambiguity of this sort; see e.g. Brennan 1993 and references cited there for modal auxiliaries, and Jacobson 1992 and references cited there for main verbs like 'promise,' 'permit', etc.) The assumption stated says that such an ambiguous word will act consistently raising-like on one of its readings, and consistently control-like on the other reading. This is not the same as displaying control behavior as well as raising behavior on one given reading. (Though admittedly the difference will not be easy to detect in practice.)

[42] This is not uncontroversial, however. We have been sticking here to the H&K treatment of PRO (together with the standard syntactic analysis that posits PRO as the subject of *try*'s infinitval complement) – but what if that's wrong? There *is* another (actually, a more widely assumed) analysis of PRO on the market. On that analysis, PRO is not semantically vacuous, but rather is interpreted just like other pronouns (overt personal or reflexive pronouns, and the

se, but that it is a more specific property of the function defined in (184) which disqualifies it as an available word meaning.

The intuitive idea that we will try to spell out is that there is a sort of economy condition on lexical meanings, which says that a predicate should always be analyzed as taking, in a sense to be made precise, the fewest possible number of arguments. For example, the function $[\![xxx]\!]^{w,[\mathbf{R}\rightarrow R]}$ in entry (184) is a function of *two* arguments (a property and an individual), but that 2-place function is (as we already noted in section 5.1) definable in terms of another function with only *one* argument (viz. that function from *propositions* to truth-values which was our original denotation for *must-R*). So in some sense, $[\![xxx]\!]^{w,[\mathbf{R}\rightarrow R]}$ takes one more argument than it "needs" to take, and we are speculating that this is what UG objects to.

In making this constraint precise, we have to avoid the danger of ruling out *all* functions of more than one argument. The problem here is that in principle it is *always* possible to define an n-place function in terms of an n-1 place function (or, for that matter, in terms of a 1-place function). For example (as we explained at length in the introduction to Schönfinkelization[43]), any 2-place function f of type <e,et> can be defined in terms of a 1-place function F whose arguments are *ordered pairs* of individuals: F = λ<x,y>.f(x)(y) iff f = λx.λy.F(<x,y>). But we don't want to block the existence of run-of-the-mill transitive verb denotations just because they are definable in terms of 1-place properties of ordered pairs of individuals. Fortunately, there is a relevant difference between this case and the case that we do want to prohibit. Notice that there is no semantic composition rule that puts two individuals together into an ordered pair. Therefore, the 1-place "competitor" for a 2-place verb of type <e,et> could never project an interpretable structure: it would have to have a single sister-node which denotes an ordered pair, but there are no such nodes. The situation is otherwise with the 1-place necessity operator (type <st,t>) which we do want to compete successfully with the corresponding 2-place function of type <<s,et>,et>. There *is* an appropriate composition principle (viz. FA) which allows us to interpret a single constituent constructed out of the predicate and

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"little" *pro* of Pro-Drop languages), namely as a variable. It differs from these other pronouns (just as they differ among themselves) only syntactically, in being subject to its own distinctive licensing and "Binding" conditions (e.g. a Minimal Distance Principle à la Rosenbaum). These will somehow make sure that in every well-formed LF PRO will be coindexed with (the trace of) a certain other DP (the so-called controller). On that alternative approach to PRO, the semantic type of subject-control verbs like *try* will not be <<s,et>,et>, but rather <st,et> (the same type as e.g. *believe*). So perhaps the type <<s,et>,et> is not, after all, needed for anything, and we may simply have a UG constraint that excludes *xxx* along with *all* meanings of the same type.

This possibility raises complex issues way beyond the scope of the present discussion. We would have to get deeply into the arguments which have been brought to bear on the proper semantic treatment of PRO, so that we could make an informed choice between the H&K vacuous PRO (which basically is an implementation of the approach advocated by Chierchia 1984 and his followers) and the more commonly assumed pronoun-like PRO. To complicate matters, there is also the possibility that both kinds of PROs exist side-by-side in natural language, as argued in recent work by Idan Landau. (Landau 1999a *Elements of Control*, MIT Ph.D. thesis; 1999b 'Psych-adjectives and semantic selection,' *The Linguistic Review* 16, pp. 333-358.) In sum, the view of control-verbs which we are presupposing in the text here may be wrong, and this could very well make obsolete the constraint we are about to propose.

[43]See H&K, ch. 2, sec. 4.

the name that would otherwise be two separate arguments, and this does yield the required kind of argument for the 1-place operator.

So here is a first pass at stating the hypothesized universal.

(189)   There are no lexical predicates which always (i.e., w.r.t. all w and g) denote functions that take *too many arguments* (in the sense of the following definition).

(190)   *Definition*: A function f of type $\langle\sigma,\langle\tau,\dots\rangle\rangle$ *takes too many arguments* iff there is a function f' such that, for all x_σ and y_τ: f(x)(y) = f'([x,y]).

(191)   *Definition*: [x,y] is the semantic object (if any) that can be obtained by putting x and y together in one of the following ways (whichever one is defined): [x,y] = x(y), or [x,y] = λw.x(w)(y), or [x,y] = λw.x(y(w)), or [x,y] = λw.x(w)(y(w)).

To see how (189) is meant to apply, let's show first that our hypothetical modal *xxx* defined in (184) above always "takes too many arguments", and then let's show that an ordinary transitive verb of type <e,et> does not always take too many arguments, and neither does a real control verb.
According to definition (190), to show that *xxx* always takes too many arguments, we must show that, for arbitrary w and g, there is a function f' such that $[\![xxx]\!]^{w,g} = \lambda P\langle s,et\rangle.\lambda x_e.f'([P,x])$. We claim that f' := $\lambda p_{\langle s,t\rangle}.\forall w'\in g(R)(w)$: p(w')=1 is such a function. Proof:

(192) $\lambda P\langle s,et\rangle.\lambda x_e.f'([P,x])$ = (by our def. of f')
         $\lambda P\langle s,et\rangle.\lambda x_e.[\forall w' \in g(R)(w): [P,x](w') = 1]$ = (by def. (7))
         $\lambda P\langle s,et\rangle.\lambda x_e.[\forall w' \in g(R)(w): P(w')(x) = 1]$ = (by entry (1))
         $[\![xxx]\!]^{w,g}$ QED

In other words, the fact that $[\![xxx]\!]^{w,g}$ is definable in terms of the type-<st,t> denotation for *must-R* is the reason why $[\![xxx]\!]^{w,g}$ takes too many arguments.

Why does the extension of a transitive verb like *eat* not always (in fact, never) take too many arguments? Because any x and y which are suitable arguments for $[\![eat]\!]^w$ are both of type e, and therefore [x,y] is not defined (see def. (191)). So there couldn't possibly be a function f' that would be definable with reference to [x,y] as specified in (190). In other words, definition (191) serves to spell out our earlier informal idea that x and y would have to be combinable by a standard composition operation into a single semantic object. What it says, in effect, is that x or the extensions of x must be functions that can apply to y or the extensions of y.[44]

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[44]The informal idea actually was a bit more general. It implied that if the grammar makes use of other general modes of composition besides (some versions of) functional application, then those should also be considered here. So for example, since we do a have a rule of Predicate Modification, we may want to extend the definition in (191) so that [x,y] can also be either $\lambda z_e.x(z) = y(z) = 1$ or $\lambda w.\lambda z_e.x(w)(z) = y(w)(z) = 1$ (provided that the types of x and y are suitable, i.e. they are either both <e,t> or both <s,et>). You may want to think about the empirical implications of this revision. (Hint: Look at determiner denotations, which are functions of type <et,<et,t>>. Would some of these now turn out to be taking too many arguments?)

Finally, we want to make sure that genuine control verbs are not prohibited. As an example, consider this entry for (one reading of) *want* (the one that takes infinitival complements with PRO subjects[45]).

(193) $\llbracket want \rrbracket^w =$
          $\lambda P_{\langle s,et \rangle}.\lambda x_e.\forall w'[w'$ is compatible with what x wants in w $\rightarrow$ P(w')(x) $= 1]$

Now we will show that, for at least some worlds w, $\llbracket want \rrbracket^w$ does not take too many arguments, and we will do this by assuming the contrary and deriving a contradiction. Let w be a world in which John (=: j) wants to live with Mary (=: m), but m does not want to live with j. If (for this choice of w) $\llbracket want \rrbracket^w$ took too many arguments, then there would be a function f' such that $\llbracket want \rrbracket^w = \lambda P.\lambda x.f'([P,x])$. Now consider the function $\lambda w'.\lambda x.\lambda y$. y lives with x in w' (=: L). Given that $\llbracket want \rrbracket^w = \lambda P.\lambda x.f'([P,x])$, it follows in particular that $\llbracket want \rrbracket^w([L,m])(j) = f'([[L,m],j])$ and that $\llbracket want \rrbracket^w([L,j])(m) = f'([[L,j],m])$. By definition of L (and def. (191)), $[[L,m],j] = [[L,j],m]$. Therefore, $f'([[L,m],j]) = f'([[L,j],m])$, and therefore $\llbracket want \rrbracket^w([L,m])(j) = \llbracket want \rrbracket^w([L,j])(m)$. Now, given (193) and our description of w, $\llbracket want \rrbracket^w([L,m])(j) = 1$. (This is because j does live with m in every world compatible with j's desires in w.) But for analogous reasons, $\llbracket want \rrbracket^w([L,j])(m) = 0$. (Because m does not live with j in every world compatible with m's desires in w.) *Contradiction.*

It appears, then, that the universal constraint on predicates that we have proposed in (189) succeeds in ruling out the hypothetical verb *xxx* with the meaning defined in (184), while not ruling out the verb *want* with the meaning in (193), which is of the same semantic type. More generally, we have grounds to conjecture that (189) will rule out *any* potential predicate which would display a mixture of "control" and "raising" properties, i.e., any potential counterexample to the Clustering Assumption. This, of course, is a much more general claim than what we have been able to prove here. You are invited to plot proofs for further sub-claims of it, and thus develop at least a feel for its plausibility.

As it turns out, if the constraint in (189) is adopted (because of the motivation for it that we have given, viz. the need to rule out items like *xxx*), then it will automatically also rule out certain kinds of lexical entries which we don't have any independent compelling reason to rule out. As a case in point, consider the type-$\langle\langle s,et \rangle,\langle\langle s,\langle et,t \rangle\rangle,t \rangle\rangle$ entries for modals which we constructed in section 5.2. Unlike with the simpler type-$\langle\langle s,et \rangle,et \rangle$ entries, we were not able to show that these entries would predict a mixed pattern of raising and control behaviors in violation of the Clustering Assumption, at least not if we can't refute the ugly-object analysis of expletives. So we didn't have a direct argument for constraining the lexicon in such a way as to exclude those entries. But as it happens, the constraint in (189) will cover them too: they too define denotations that systematically take too many arguments in the sense of definition (190).

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[45]The implicit assumption here is that this is a different homonym of *want* than the one that takes infinitives with overt subjects. This is *prima facie* unattractive and perhaps wrong. A unified analysis of *want* for both types of environments would be preferable, but in order to give one, it seems we would have to rethink our treatment of PRO. See footnote 56 above. We disregard this objection here for the sake of being able to illustrate our point in the text with an example of a verb whose meaning is relatively easy to define.

So we have indirect reason to suspect, after all, that they are not possible meanings for natural language modal predicates either – which is just as well, since it further reduces the options to be considered by the language learner and makes more of a predicate's syntax predictable from its semantics.

In a roundabout way, then, we have finally motivated what we initially just assumed for expository convenience: namely that the so-called "raising" predicates (i.e., predicates which exhibit that certain cluster of behaviors) should indeed be analyzed as involving "raising" (i.e., movement) in the syntax and taking single, propositional, arguments in the semantics. Of the alternative analyses that we considered, some could be discarded quickly as descriptively inadequate (i.e., as unable to predict the observed properties of these particular predicates). Others, however, could only be dismissed after we brought in considerations of explanatory adequacy as well and tried to say something substantive about the universal inventory of possible predicate meanings.

5.5.1   Appendix

The implementation of our universal constraint in (189) and (190) may not be sufficiently general. In our discussion, we only considered the case where a potential *2*-place predicate is ruled out by the existence of a competing *1*-place predicate. But we also want to rule out certain *3*-place predicates when there are competing *2*-place predicates. For example, we want to make sure that a verb with the characteristic phenomenology of "raising-to-object" (="ECM") verbs is forced to have a denotation of type $<st,et>$, and cannot be analyzed as of type $<<s,et>,<e,et>>$ instead. (The latter type should, however, be available for so-called "object-control" verbs.[46]) We also want to make sure that a "raising-to-subject" verb which happens to take an additional argument, such as *seem* in 'John seems *to Mary* to be tired', must still be only 2-place (type $<st,et>$) and not 3-place (type $<<s,et>,<e,et>>$). Moreover, we may want to take into account that modal auxiliaries on our official analysis were really of type $<st,<st,t>>$, not of type $<st,t>$. ($<st,t>$ was rather the type of the complex consituent containing the modal and its covert restrictor.) So if our constraint is meant to be about lexical items, it should apply in such a ways as to rule out an $<st,<<s,et>,et>>$-

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[46] We are assuming here, without actually reviewing the pertinent evidence, that "raising-to-object" and "object-control" predicates are also distinguished by a whole cluster of properties, and that again a version of the Clustering Assumption (i.e., no mixed behavior) is empirically correct. The relevant literature indeed suggests that the situation here is analogous to the one with "raising-to-subject" vs. "subject-control". Notice, however, that the existence of a syntactic operation of raising to object is much harder to show than the existence of raising to subject. In the case of "raising-to-subject" verbs, once we have motivated that they must have denotations of type $<st,t>$, we are forced to derive the observed surface word order by movement of the subject. But when we have decided that "raising-to-object" verbs must have denotations of type $<st,et>$, we are still free to entertain a syntactic analysis where the embedded infinitive's subject stays *in situ* throughout the derivation. (This, indeed, is the "Exceptional Case Marking" analysis advocated in Chomsky's LGB.) The difference is simply that raising to object, if it does exist, is (usually) a string-vacuous operation, and therefore much harder to establish without non-trivial syntactic analysis. So our constraint on the lexicon, as applied to "raising-to-object" verbs, will enforce a semantic type which is incompatible with an analysis where the apparent object *originates* as an object of the higher verb, but is compatible equally with raising to object and with exceptional case marking *in situ*.

entry in favor of an **<st,<st,t>>** entry, i.e., a 3-place entry in favor of a 2-place one.

Some of the cases we have just listed may already be covered by definition (190) as it stands, even though we were only thinking of 2-place comepeting with 1-place when we wrote it. Notice that (190) does not actually require that f be "2-place" in the sense of taking (exactly) 2 arguments before it yields a truth-value. It only requires that f takes *at least* 2 arguments before it yields a saturated meaning. So (190) can be applied to 3-place predicates and will properly identify some of these as "taking too many arguments". But the way it is written, it only works when, informally speaking, the "excess" argument happens to be the 2nd-lowest one. Therefore (unless other principles of UG conspire to independently rule out many of the conceivable argument structures) it probably doesn't cover all the cases we want it to. For example, consider the following two versions of a 3-place analysis of (infinitve-embedding) *believe*:

(194) $[\![believe]\!]^w =$
           $\lambda y_e.\lambda P_{<s,et>}.\lambda x_e.\forall w'[w'$ is compatible with what x believes in w $\rightarrow$ P(w')(y) = 1]

(195) $[\![believe]\!]^w =$
           $\lambda P_{<s,et>}.\lambda y_e.\lambda x_e.\forall w'[w'$ is compatible with what x believes in w $\rightarrow$ P(w')(y) = 1]

The entry in (194) fits a syntax where the VP is left-branching, so that *believe* combines first with its object and then with the infinitive. The one in (195) fits a Larsonian-style analysis, where *believe* orginates (and reconstructs to) a position between the object and infinitive, thus taking the infinitive as its innermost argument. We'd like to make sure that either one of these is correctly branded as taking too many arguments due to the existence of the 2-place competitor in (196).

(196) $[\![believe]\!]^w =$
           $\lambda p_{<s,t>}.\lambda x_e.\forall w'[w'$ is compatible with what x believes in w $\rightarrow$ p(w') = 1]

But only (195) actually qualifies as taking too many arguments according to our current definition (190). (*Exercise*: Explain why this is so.) Similar comments apply to the other cases we mentioned.

So, just to be on the safe side, let's fix this limitation There are a variety of technical options, but the easiest one, it seems, is to revise the definition in (190) so as to explicitly ensure that, whenever you "switch around" the arguments of a function that takes too many arguments, the new function you thereby obtain will still take too many arguments. Here is a way to express this:

(197)   *Definition*: f' is a *permutation-variant* of f iff there is an n-place function F (for some n) such that both f and f' are Schönfinkelizations of this same F.[47]

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[47] Recall the discussion of different ways to schönfinkel 2-place functions in 3-place functions

(198)   *Definition* (replaces (190) above):
       A function f *takes too many arguments* iff
       either
       (i) f is of type $\langle\sigma,\langle\tau,\ldots\rangle\rangle$ and there is a function f' such that, for all
       x_σ and y_τ: f(x)(y) = f'([x,y]);
       or
       (ii) f is a permutation-variant of a function that meets condition (i).

The effect of this revision is that when we want to know whether a given function takes too many arguments, we now don't need to check this function itself, but can check any permutation-variant instead. For example, given that the 3-place denotation defined for *believe* in (195) takes too many arguments according to clause (i) of definition (12), it follows automatically by clause (ii) that the variant in (194) likewise takes too many arguments, as does any other Schönfinkelization of the same 3-place relation. So our universal (190) will now rule out all of them at once. The story about the other cases mentioned above is similar.

6   A Closer Look at the de re-de dicto Distinction

6.1   A problem: additional readings and scope paradoxes

Janet Dean Fodor discusses examples like (199) in her 1970 dissertation.[48]

(199)   Mary wanted to buy a hat just like mine.

Fodor observes that (199) has three readings, which she labels "specific *de re*," "non-specific *de re*," and "non-specific *de dicto*." (i) On the "specific *de re*" reading, the sentence says that there is a particular hat which is just like mine such that Mary has a desire to buy it. Say, I am walking along Newbury Street with Mary. Mary sees a hat in a display window and wants to buy *it*. She tells me so. I don't reveal that I have one just like it. But later I tell *you* by uttering (199). (ii) On the "non-specific *de dicto*" reading, the sentence says that Mary's desire was to buy some hat or other which fulfills the description that it is just like mine. She is a copycat. (iii) On the "non-specific *de re*" reading, finally, the sentence will be true, e.g., in the following situation: Mary's desire is to buy some hat or other, and the only important thing is that it be a chapeau-claque. Unbeknownst to her, my hat is one of those as well.

The existence of three different readings appears to be problematic for our scopal account of *de re-de dicto* ambiguities. It seems that our analysis allows just two semantically distinct types of LFs: Either the DP *a hat just like mine* takes scope below *want*, as in (200), or it takes scope above *want*, as in (201).

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in H&K ch.2, sec. 4. (E.g. "left to right" and "right to left", or "right to middle to left", "middle to left to right",....)

[48]Fodor, Janet Dean (1970) *The Linguistic Description of Opaque Contexts.* Ph.D. Dissertation, Massachusetts Institute of Technology. [Published in 1976 by Indiana University Linguistics Club and in 1979 in the Series "Outstanding Dissertations in Linguistics" by Garland.]

(200)   Mary wanted [[a hat-just-like-mine]$_1$ [to buy t$_1$]]

(201)   [a hat-just-like-mine]$_1$ [Mary wanted [to buy t$_1$]]

(200) says that in every world w' in which Mary gets what she wants, there is something that she buys in w' that's a hat in w' and like my hat in w'. This is Fodor's "non-specific *de dicto*" reading. (201), on the other hand, says that there is some thing x which is a hat in the actual world and like my hat in the actual world, and Mary buys x in every one of her desire worlds. That is Fodor's "specific *de re*." But what about the "non-specific *de re*"? To obtain this reading, it seems that we would have to evaluate the predicate *hat just like mine*

in the actual world, so as to obtain its actual extension (in the scenario we have sketched, the set of all chapeau-claques). But the existential quantifier expressed by the indefinite article in the *hat*-DP should not take scope over the modal operator *want*, but below it, so that we can account for the fact that in different desire-worlds of Mary's, she buys possibly different hats. There is a tension here, what has been called a "scope paradox": one aspect of the truth-conditions of this reading suggests that the DP *a hat just like mine* should be *outside* of the scope of *want*, but another aspect of these truth-conditions compels us to place it *inside* the scope of *want*. We can't have it both ways.

Another example of this sort, due to Bäuerle (1983)[49], is (202):

(202)   Georg believes that a woman from Stuttgart loves every member of the VfB team.

Bäuerle describes the following scenario: Georg has seen a group of men on the bus. This group happens to be the VfB team (Stuttgart's soccer team), but Georg does not know this. Georg also believes (Bäuerle doesn't spell out on what grounds) that there is some woman from Stuttgart who loves every one of these men. There is no particular woman of whom he believes that, so there are different such women in his different belief-worlds. Bäuerle notes that (202) can be understood as true in this scenario. But there is a problem in finding an appropriate LF that will predict its truth here. First, since there are different women in different belief-worlds of Georg's, the existential quantifier *a woman from Stuttgart* must be inside the scope of *believe*. Second, since (in each belief world) there aren't different women that love each of the men, but one that loves them all, the *a*-DP should take scope over the *every*-DP. If the *every*-DP is in the scope of the *a*-DP, and the *a*-DP is in the scope of *believe*, then it follows that the *every*-DP is in the scope of *believe*. But on the other hand, if we want to capture the fact that the men in question need not be VfB-members in Georg's belief-worlds, the predicate *member of the VfB team* needs to be outside of the scope of *believe*. Again, we have a "scope paradox".

[49]Bäuerle, Rainer (1983) "Pragmatisch-semantische Aspekte der NP-Interpretation," in M. Faust et al. (eds.) *Allgemeine Sprachwissenschaft, Sprachtypologie und Textlinguistik*, Tübingen: Narr, pp. 121 - 131. A brief summary (in English) of this paper can be found in R. Musan (1995) *On the Temporal Interpretation of Noun Phrases*, MIT Ph.D. thesis (MITWPL; also Garland 1997), ch. V, sec. 3.2.

Similar examples are discussed in Hellan (1978), Bonomi (1995), Farkas (1997), and other places.[50] The point that all these authors have made is that the NP-predicate restricting a quantifier may be evaluated in the actual world, even when that quantifier clearly takes scope below a modal predicate. Before we turn to possible solutions for this problem, let's have one more example:

(203)   Mary hopes that a friend of mine will win the race.

This again seems to have three readings. In Fodor's terminology, the DP *a friend of mine* can be "non-specific *de dicto*," in which case (203) is true iff in every world where Mary's hopes come true, there is somebody who is my friend and wins. It can also have a "specific *de re*" reading: Mary wants John to win, she doesn't know John is my friend, but I can still report her hope as in (203). But there is a third option, the "non-specific *de re*" reading. To bring out this rather exotic reading, imagine this: Mary looks at the ten contestants and says *I hope one of the three on the right wins - they are so shaggy - I like shaggy people.* She doesn't know that those are my friends. But I could still report her hope as in (203).

6.2   The standard solution: overt world variables

The scope paradoxes we have encountered can be traced back to a basic design feature of our system of intensional semantics: The relevant "evaluation world" for each predicate in a sentence is strictly determined by its LF-position. All predicates that occur in the (immediate) scope of the same modal operator must be evaluated in the same possible worlds. E.g. if the scope of *want* consists of the clause *a friend of mine (to) win*, then every desire-world w' will be required to contain an individual that wins in w' and is also my friend *in w'*. If we want to quantify over individuals that are my friends in the actual world (and not necessarily in all the subject's desire worlds), we have no choice but to place *friend of mine* outside of the scope of *want*. And if we want to accomplish this by means of QR, we must move the entire DP *a friend of mine*.

Not every kind of intensional semantics constrains our options in this way. Consider the following alternative.

6.2.1   Semantic values

In this new system, we do *not* relativize the interpretation function to a possible world. As in the old extensional system, the basic notion is just "$[\![\alpha]\!]$," i.e., "the

[50]Ioup, Georgette (1977) "Specificity and the Interpretation of Quantifiers," *Linguistics and Philosophy* 1.2, pp. 233 - 245. Hellan, Lars (1978) "On Semantic Scope," in Heny, Frank (ed.) (1978) *Ambiguities in Intensional Contexts*, Dordrecht: Reidel. Abusch, Dorit (1994) "The Scope of Indefinites." *Natural Language Semantics 2*: 83-135, section 6. "First alternative: non-local determination of the content of the restrictive property," pp. 103ff. Bonomi, Andrea (1995) "Transparency and Specificity in Intentional Contexts," in P. Leonardi and M. Santambrogio (eds.) *On Quine*, Cambridge University Press, pp. 164 - 185. [sec. II "Specificity", pp. 172ff.]. Farkas, Donka (1997) "Evaluation Indices and Scope," in A. Szabolcsi (ed.) *Ways of Scope Taking*, Dordrecht: Kluwer, pp. 183 - 215.

semantic value of α". (Or "$[\![\alpha]\!]^g$," "the semantic value of α under assignment g", if α contains free variables.) However, semantic values are no longer always extensions; some of them still are, but others are intensions. Here are some representative examples of the types of semantic values for various kinds of words.

6.2.2   Lexical entries

(204) a. $[\![smart]\!]$ = $\lambda w \in D_s$. $\lambda x \in D_e$. x is smart in w
       b. $[\![likes]\!]$ = $\lambda w \in D_s$. $\lambda x \in D_e$. $\lambda y \in D_e$. y likes x in w
       c. $[\![teacher]\!]$ = $\lambda w \in D_s$. $\lambda x \in D_e$. x is a teacher in w
       d. $[\![friend]\!]$ = $\lambda w \in D_s$. $\lambda x \in D_e$. $\lambda y \in D_e$. y is x 's friend in w

(205) a. $[\![believe]\!]$ = $\lambda w \in D_s$. $\lambda p \in D_{\langle s,t \rangle}$. $\lambda x \in D$. $\forall w'$ [w' conforms to what x believes in w $\rightarrow$ p(w') = 1]
       b. $[\![must]\!]$ = $\lambda w \in D_s$. $\lambda R \in D_{\langle s,st \rangle}$. $\lambda p \in D_{\langle s,t \rangle}$. $\forall w'$ [R(w)(w') = 1 $\rightarrow$ p(w') = 1]

(206) a. $[\![Ann]\!]$ = Ann
       b. $[\![and]\!]$ = $\lambda u \in D_t$. [$\lambda v \in D_t$. u=v=1]
       c. $[\![the]\!]$ = $\lambda f \in D_{\langle e,t \rangle}$: $\exists!x$. f(x) = 1. the y such that f(y) = 1.
       d. $[\![every]\!]$ = $\lambda f \in D_{\langle e,t \rangle}$. $\lambda g \in D_{\langle e,t \rangle}$. $\forall x$ [f(x) = 1 $\rightarrow$ g(x) = 1]

The entries in (206) (for words whose extensions are constant across worlds) have stayed the same; their semantic values are still extensions. But the ones for predicates (ordinary ones and modal ones) in (204) and (205) have changed; these items now have as their semantic values what used to be their *intensions*.

6.2.3   Composition rules

We abolish the special rule of Intensional Functional Application (IFA)[51] and go back to our old inventory of Functional Application, λ-Abstraction, and Predicate Modification[52].

6.2.4   Syntax

What we have at this point does not allow us to interpret even the simplest syntactic structures. For instance, we can't interpret the tree in (207).

(207)   [$_{VP}$ John leave]

The verb's type is <s,et>, so it's looking for a sister node which denotes a *world*. *John*, which denotes an individual, is not a suitable argument.

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[51] We also abolish the Extensional Functional Application rule (EFA), if we had that one (see section 4.2.3 "Semantic Reconstruction").

[52] Actually, PM requires a slightly revised formulation: $[\![\alpha\beta]\!]^g = \lambda w \in D_s. \lambda x \in D_e$. $[\![\alpha]\!]^g$(w)(x) = $[\![\beta]\!]^g$(w)(x) = 1. But we will not be concerned with the compositional interpretation of modifier-structures here, so you won't be needing this rule.

We get out of this problem by positing more abstract syntactic structures (at the LF level). Specifically, we assume that there is a set of covert "world pronouns" which are generated as sisters to all lexical predicates in LF-structures. We distinguish two syntactic types of world-pronouns. One type, w-PRO, behaves like relative pronouns and PRO in the analysis of H&K, ch. 8.5 (pp. 226ff.): it is semantically vacuous itself, but can move and leave a trace that is a variable. The only difference between w-PRO and PRO is that the latter leaves a variable of type e when it moves, whereas the former leaves a variable of type s. The other type of world-pronoun, w-pro, is analogous to bound-variable personal pronouns, i.e., it is itself a variable (here of type s). Like a personal pronoun, it can be coindexed with the trace of an existing movement chain.

What is the syntactic distribution of w-PRO and w-pro? We assume that it is constrained by a kind of "Binding Theory" that remains to be worked out. For the time being, we stipulate that w-pro is only generated in the immediate scope of a determiner (i.e., as sister to the determiner's argument). Everywhere else where a world-pronoun is needed for interpretability, we must generate a w-PRO and move it.[53]

Consider a simple sentence like *John left*. In order to get around the type-mismatch in (207) above, we must generate a w-PRO next to the verb and move it to some position above *John* (where exactly doesn't matter – we leave this open, and in fact omit all vacuous nodes from the trees below). So the LF of the sentence is something like (208), and its interpretation is calculated below.

(208)   [w-PRO λ_1 [$_{VP}$ John [$_V$ leave t$_{s,1}$]]]

$[\![(208)]\!]$ = (by vacuity of w-PRO and λA)
$\lambda w.\ [\![\textit{John leave } t_1]\!]^{[<s,1> \to w]}$ = (by FA twice)
$\lambda w.\ [\![\textit{leave}]\!](w)([\![\textit{John}]\!])$ = (by lexical entries)
$\lambda w.\ \text{John leaves in } w$

So the semantic value of (208) is a proposition, the proposition that John left. Sentences generally denote propositions (rather than truth values) in this new framework. Still, of course, we want to account for the fact that speakers have judgments about the truth and falsity of utterances. The connection between semantic values and truth is captured in the following general definition:

(209)   An utterance of a sentence (=LF) ϕ is true iff $[\![\phi]\!]$ maps the world in which the utterance occurs to 1. (Similarly for "false".)

So we predict that utterances of (208) are true iff they are performed in possible worlds in which John leaves.

Let's proceed to an example with a modal, say the sentence *John must leave*. As before, we adopt a raising analysis of modals and assume for simplicity that

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[53]The idea that there is a syntactic Binding Theory for world-variables, as well as our specific stipulation here, are inspired by Percus (1998, 2000). (Percus, Orin (1998) "Instructions for the Worldly," WCCFL 17. Percus, Orin (2000) "Constraints on Some Other Variables in Syntax," *Natural Language Semantics* 8.3, pp. 173-229). For an earlier hint in this direction, see I. Heim (1991) "Artikel und Definitheit," in A. v. Stechow & D. Wunderlich (eds.) *Semantics. An International Handbook of Contemporary Research*, Berlin: de Gruyter, pp. 487 - 535, section 1.3.3. (pp. 502 - 505).

the subject has been reconstructed to its VP-internal position. The minimal LF-structure then would be (210), but again this is uninterpretable.

(210)   [[must R] [John leave]]

We can resolve all the type-mismatches in (210) by inserting a *w*-PRO next to *leave*, moving it above *John* but no higher than the modal, inserting another *w*-PRO next to *must*, and moving that one above everything else. This amounts to the LF in (211), with the denotation indicated underneath. (R is the contextually supplied accessibility relation that's the value of *R*.)

(211)   [w-PRO λ_2 [[[must $t_{s,2}$] R] [w-PRO λ_1 [VP John [leave $t_{s,1}$]]]]]

$\lambda w.\ \forall w'[w' \in R(w) \to \text{John leaves in } w']$

Exercise 19

Show how the semantic value of (211) is calculated.

Now we turn to an example with a complex DP, let's say, *the teacher left*. The verb will need a world argument as before. The noun *teacher* will likewise need one, so that *the* can get the required argument of type <e,t> (not <s,et>!). As we stipulated above, the world arguments of nouns in DPs are *w-pro* rather than *w*-PRO; they are inherently variables and get bound by coindexing with the tail of a preexisting movement link. Taking all this into account, we arrive at the LF and denotation in (212).

(212)   [w-PRO λ_1 [VP [DP the [teacher w-pro$_!$]] [leave $t_{s,1}$]]]

$\lambda w.$ the one who is a teacher in w leaves in w

So far, we have still been deriving all the same truth-conditions that we predicted in the old system, albeit in a more round-about way. With the next example, however, we are getting to the substantive differences between the frameworks.

Consider what happens when the sentence contains both a modal operator and a complex DP in its complement.

(213)   Mary wants a friend of mine to win.

Like in the old framework, we assume that the DP *a friend of mine* may either stay *in situ* at LF or else move out of the scope of *want*. But unlike in the old framework, the DP *a friend of mine* contains a *w-pro* which gets bound by one of the *w*-PRO's that have moved above it. If the DP has QRed into the matrix clause, the only possible binder for this *w-pro* is the *w*-PRO that comes from the argument position of *want*. But if the DP has stayed in the embedded clause, we have two distinct choices. We can bind the *w-pro locally*, i.e. coindex it with the world-argument of the verb in its own clause (= *win*). Or we can bind it *non-locally*, by coindexing it with the world-argument of the higher verb (= *want*). So altogether we can generate three distinct LFs:

(214)   DP in matrix clause:
        [w-PRO λ_2 [[$_{DP}$ a [f-o-m w-pro$_2$]] λ_3 [Mary [[want t$_{s,2}$] [w-PRO λ_1 [t$_{e,3}$ [win t$_{s,1}$]]]]]]]]

(215)   DP in complement clause; locally bound *w-pro*:
        [w-PRO λ_2 [[Mary [[want t$_{s,2}$] [w-PRO λ_1 [[$_{DP}$ a [f-o-m w-pro$_1$]] [win t$_{s,1}$]]]]]]]

(216)   DP in complement clause; distantly bound *w-pro*:
        [w-PRO λ_2 [[Mary [[want t$_{s,2}$] [w-PRO λ_1 [[$_{DP}$ a [f-o-m w-pro$_2$]] [win t$_{s,1}$]]]]]]]

Exercise 20

Work out the truth-conditions of (214)-(216) step by step.

As it turns out, (214) has exactly the truth-conditions of a *de re*-LF in our old framework. It is true in the actual world iff there is some actual friend of mine who wins in each of Mary's desire worlds. In Fodor's terminology, then, this is the 'specific *de re*' reading. (215) is equivalent to a *de dicto*-LF in our old framework. It says that in each of Mary's desire worlds, there is someone or other who is my friend there and wins there. This is a *de dicto* or 'non-specific *de dicto*' reading[54]. The interesting case is (216). This LF is true in the actual world iff each of Mary's desire worlds contains an *actual* friend of mine who wins there. In distinction to (214), it is not required that the same actual friend wins in every desire world. And in distinction to (215), it is not required that any of the people who win in Mary's desire worlds are friends of mine in those desire worlds. (216) is thus a representation for the "non-specific *de re*" reading which we set out to capture.

In this new framework, then, we have a way of resolving the apparent "scope paradoxes" and of acknowledging Fodor's point that there are two separate distinctions to be made when DPs interact with modal operators. First, there is the scopal relation between the DP and the operator; the DP may take wider scope (Fodor's "specific" reading) or narrower scope ("non-specific" reading) than the operator. Second, there is the choice of binder for the world-argument of the DP's restricting predicate; this may be cobound with the world-argument of the embedded predicate (Fodor's "*de dicto*") or with the modal operator's own world-argument ("*de re*"). So the *de re-de dicto* distinction in the sense of Fodor is not *per se* a distinction of scope; but it has a principled connection with scope in one direction: Unless the DP is within the modal operator's scope, the *de dicto* option (=cobinding the world-pronoun with the embedded predicate's world-argument) is in principle unavailable. (Hence "specific" implies "*de re*", and "*de dicto*" implies "non-specific".) But there is no implication in the other direction: if the DP has narrow scope w.r.t. to the modal operator, either the local or the long-distance binding option for its world-pronoun is in principle available. Hence "non-specific" readings may be either "*de re*" or "*de dicto*".

For the sake of clarity, we should introduce a different terminology than Fodor's. The labels "specific" and "non-specific" especially have been used in so many

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[54]Since there is no such thing as a "specific *de dicto*" reading (for principled reasons – see right below), the Fodor terminology is redundant in this case: "*de dicto*" automatically implies "non-specific".

different senses by so many different people that it is best to avoid them altogether. So we will refer to Fodor's "specific readings" and "non-specific readings" as "wide-quantification readings" and "narrow-quantification readings", or "narrow-Q/wide-Q readings" for short. For the distinction pertaining to the interpretation of the restricting NP, we will keep the terms "*de re*" and "*de dicto*", but will amplify them to "restrictor-*de re*" and "restrictor-*de dicto*" ("R-*de re*"/"R-*de dicto*").

Exercise 21

For DPs with extensions of type e (specifically, DPs headed by the definite article), there is a truth-conditionally manifest R-*de re*/R-*de dicto* distinction, but no truth-conditionally detectable wide-Q/narrow-Q distinction. In other words, if we construct LFs analogous to (214)-(216) above for an example with a definite DP, we can always prove that the first option (wide scope DP) and the third option (narrow scope DP with distantly bound world-pronoun) denote identical propositions. In this exercise, you are asked to show this for the example in (137).

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

6.3   Excursus: Semantic reconstruction for de dicto raised subjects?

Let us look back at the account of *de dicto* readings of raised subjects that we sketched earlier in Section 4.2.4.

We showed that you can derive such readings by positing a high type trace for the subject raising, a trace of type <s,<et,t>>. Before the lower predicate can combine with the trace, the semantic value of the trace has to be extensionalized by being applied to the lower evaluation world (done via the EFA composition principle). Upstairs the raised subject has to be combined with the lambda-abstract (which will be of type <<s,<et,t>>,t>) via its intension.

We then saw recently discovered data suggesting that syntactic reconstruction is actually what is going on. This, of course, raises the question of why semantic reconstruction is unavailable (otherwise we wouldn't expect the data that we observed).

Fox (2000, p. 171, fn. 41) mentions two possible explanations: (i) "traces, like pronouns, are always interpreted as variables that range over individuals (type e)", (ii) "the semantic type of a trace is determined to be the lowest type compatible with the syntactic environment (as suggested in Beck 1996)".

In this excursus, we will briefly consider whether our new framework has something to say about this issue. Let's figure out what we would have to do in the new framework to replicate the account of Section 4.2.4.

Downstairs, we would have a trace of type <s,<et,t>>. To calculate its extension, we do not need recourse to a special composition principle, but can simply give it a world-argument (co-indexed with the abstractor resulting from the movement of the w-PRO in the argument position of the lower verb).

Now, what has to happen upstairs? Well, there we need the subject to be of type <s,<et,t>>, the same type as the trace, to make sure that its semantics will enter the truth-conditions downstairs. But how can we do this?

We need the DP *somebody from New York* to have as its semantic value an intension, the function from any world to the existential quantifier over individuals who are people from New York in that world. This is actually hard to do in our system. It *would* be possible if (i) the predicate(s) inside the DP received w-PRO as their argument, and if (ii) that w-PRO were allowed to moved to adjoin to the DP. If we manage to rule out at least one of the two preconditions on principled grounds, we would have derived the impossibility of semantic reconstruction as a way of getting *de dicto* readings of raised subjects.

(i) may be ruled out by the Binding Theory for world pronominals, when it gets developed.

(ii) may be ruled out by principled considerations as well. Perhaps, world-abstractors are only allowed at sentential boundaries. See Larson "The Grammar of Intensionality" for some discussion of recalcitrant cases, one of which is the object position of so-called intensional transitive verbs, the topic of Section 7.

– End of Excursus –

6.4   Alternatives to overt world variables

We presented (a variant of) what is currently the most widely accepted solution to the scope paradoxes, which required the use of non-locally bound world-variables. Suppose we didn't give up our previous framework, in which the evaluation-world for any predicate was strictly determined by its LF-position. It turns out that there is a way (actually, two ways) to derive Fodor's non-specific *de re* reading in that framework after all.

Recall again what we need. We need a way to evaluate the restrictive predicate of a DP with respect to the higher evaluation world while at the same time interpreting the quantificational force of the DP downstairs in its local clause. We saw that if we move the DP upstairs, we get the restriction evaluated upstairs but we also have removed the quantifier from where it should exert its force. And if we leave the DP downstairs where its quantificational forces is felt, its restriction is automatically evaluated down there as well. That is why Fodor's reading is paradoxical for the old framework.

In fact, though there is no paradox.

Way #1

Raise the DP upstairs but leave a <<e,t>,t> trace. This way the restriction is evaluated upstairs, then a quantifier extension is calculated, and that quantifier extension is transmitted to trace position. This is just what we needed.

Way #2

Move the NP-complement of a quantificational D independently of the containing DP.[55] Then we could generate three distinct LFs for our sentence (213) (*Mary wants a friend of mine to win*): two familiar ones, in which the whole DP *a friend of mine* is respectively inside and outside the scope of *want*, plus a third one, in which the NP *friend of mine* is outside the scope of *want* but the remnant DP *a* [$_{NP}$ *t*] has been left behind inside it:

(218)   [[$_{NP}$ f-o-m] λ_1 [Mary [want [[$_{DP}$ a t$_{<e,t>,1}$] win]]]]

Let us calculate what this third LF means.

$$[[\text{f-o-m } 1 \text{ [Mary want a } t_1 \text{ win] }]]^w = 1$$

iff $[[1 \text{ [Mary want a } t_1 \text{ win] }]]^w \ ([[f-o-m]]^w) = 1$

iff $[[1 \text{ [Mary want a } t_1 \text{ win] }]]^w \ (\lambda x. \ x \text{ is my friend in } w) = 1$

iff $[\lambda f \in D_{<e,t>}. \ [[\text{Mary want a } t_1 \text{ win}]]^{w,[<<e,t>,1> \to f]}](\lambda x. \ x \text{ is my friend in } w$

iff $[[\text{Mary want a } t_1 \text{ win}]]^{w,[1 \to \lambda x.x is my friend in w]} = 1$

iff $[[want]]^w \ (\lambda w'. \ [[at_1 win]]^{w',[1 \to \lambda x.x is my friend in w]}) \ (\text{Mary}) = 1$

iff $[[want]]^w(\lambda w'. \ \exists y \ [\ [[t_1]]^{w',[1 \to \lambda x.x is my friend in w]} \ (y) = 1 \ \& \ [[win]]^{w'}(y) = 1]$

iff $[[want]]^w(\lambda w'. \ \exists y \ [\ [\lambda x. \ x \text{ is my friend in } w] \ (y) = 1 \ \& \ [[win]]^{w'}(y) = 1])(\text{M}$

iff $[[want]]^w(\lambda w'. \ \exists y \ [\ y \text{ is my friend in } w \ \& \ y \text{ wins in } w'])(\text{Mary}) = 1$

iff   for every w' compatible with what Mary wants in w: $\exists y \ [\ y \text{ is my friend i}$

As you can see in the last line of this calculation, the tree in (218) represents the narrow-quantification, restrictor-*de re* reading (Fodor's "non-specific *de re*").

We have found, then, that it is in principle possible after all to account for narrow-Q R-*de re* readings within our original framework of intensional semantics.

Exercise 22

(a) In (218), we chose to annotate the trace of the movement of the NP with the type-label <e,t>, thus treating it as a variable whose values are predicate-extensions (characteristic functions of sets of individuals). As we just saw, this choice led to an interpretable structure. But was it our only possible choice? Suppose the LF-structure were exactly as in (218), except that the trace had been assigned type <s,et> instead of <e,t>. Would the tree still be interpretable? If yes, what reading of sentence (213) would it express?

(b) We noted in the previous section about the world-pronouns framework that there was a principled reason why restrictor-*de dicto* readings necessarily are narrow-quantification readings. (Or, in Fodor's terms, why there is no such thing as a "specific *de dicto*" reading.) In that framework, this was simply a consequence of the fact that bound variables must be in the scope of their binders. What about the alternative account that we have sketched in the present section? Does this account also imply that R-*de dicto* readings are necessarily narrow-Q?

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[55]Something like this was proposed by J. Groenendijk & M. Stokhof ("Semantic Analysis of Wh-Complements," *Linguistics & Philosophy* 5, pp. 175 - 223) in their treatment of questions with *which*-DPs.

6.5   Quantifier scope, restrictor interpretation, and the syntax of movement

To conclude our discussion of the ambiguities of DPs in the complements of modal operators, let us consider some implications for the study of LF-syntax. This will be very inconclusive.

Accepting the empirical evidence for the existence of narrow-Q R-*de re* readings which are truth-conditionally distinct from both the wide-Q R-*de re* and the narrow-Q R-*de dicto* readings, we are facing a choice between two types of theories. One theory, which we have referred to as the "standard" one, uses a combination of DP-movement and world-pronoun binding; it maintains that wide-quantifiication readings really do depend on (covert) syntactic movement, but *de re* interpretations of the restrictor do not. The other theory, which we may dub the "scopal" account, removes the restrictor from the scope of the modal operator, either by QR (combined with an <et,t> type trace) or by movement of the NP-restrictor by itself.

In order to adjudicate between these two competing theories, we may want to inquire whether the R-*de re-de dicto* distinction exhibits any of the properties that current syntactic theory would take to be diagnostic of movement. This is a very complex enterprise, and the few results to have emerged so far appear to be pointing in different directions.

We have already mentioned that it is questionable whether NPs that are complements to D can be moved out of their DPs. Even if it is possible, we might expect this movement to be similar to the movement of other predicates, such as APs, VPs, and predicative NPs. Such movements exist, but – as discussed by Heycock, Fox, and the sources they cite[56] – they typically have no effect on semantic interpretation and appear to be obligatorily reconstructed at LF. The type of NP-movement required by the purely scopal theory of R-*de re* readings would be exceptional in this respect.

Considerations based on the locality of uncontroversial instances of QR provide another reason to doubt the plausibility of the scopal theory. May (1977) argued, on the basis of examples like (219), that quantifiers do not take scope out of embedded tensed clauses.

(219)   a.   Some politician will address every rally in John's district.
         b.   Some politician thinks that he will address every rally in John's district.

While in (219a) the universal quantifier can take scope over the existential quantifier in subject position, this seems impossible in (219b), where the universal quantifier would have to scope out of its finite clause. Therefore, May suggested, we should not attribute the *de re* reading in an example like our (220) to the operation of QR.

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

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[56]See references in the section on "Scope and syntactic Binding Conditions".

As we saw above, the standard theory which appeals to non-locally bound world-pronouns does have a way of capturing the *de re* reading of (220) without any movement, so it is consistent with May's suggestion. The purely scopal theory would have to say something more complicated in order to reconcile the facts about (219) and (220). Namely, it might have to posit that DP-movement is finite-clause bound, but NP-movement is not. Or, in the other version, it would have to say that QR can escape finite clauses but only if it leaves a <et,t> type trace.

Both theories, by the way, have a problem with the fact that May's finite-clause-boundedness does not appear to hold for all quantificational DPs alike. If we look at the behavior of *every*, *no*, and *most*, we indeed can maintain that there is no DP-movement out of tensed complements. For example, (221) could mean that Mary hopes that there won't be any friends of mine that win. Or it could mean (with suitable help from the context) that she hopes that there is nobody who will win among those shaggy people over there (whom I describe as my friends). But it cannot mean merely that there isn't any friend of mine who she hopes will win.

(221)   Mary hopes that no friend of mine will win.

So (222) has R-*de dicto* and R-*de re* readings for *no friend of mine*, but no wide-quantification reading where the negative existential determiner *no* takes matrix scope. Compare this with the minimally different infinitival complement structure, which does permit all three kinds of readings.

(222)   Mary expects no friend of mine to win.

However, indefinite DPs like *a friend of mine*, *two friends of mine* are notoriously much freeer in the scope options for the existential quantifiaction they express. For instance, even the finite clause in (223) seems to be no impediment to a reading that is not only R-*de re* but also wide-quantificational (i.e., it has the existential quantifier over individuals outscoping the universal world-quantifier).

(223)   Mary hopes that a friend of mine will win.

The peculiar scope-taking behavior of indefinites (as opposed to universal, proportional, and negative quantifiers) has recently been addressed by a number of authors (notably Abusch, Reinhart, Winter, Kratzer, Matthewson[57]), and there are good prospects for a successful theory that generates even the *wide-Q* R-*de re* readings of indefinites without any recourse to non-local DP-movement. You

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[57] Abusch, Dorit (1994) "The Scope of Indefinites." *Natural Language Semantics 2*: 83-135. Reinhart, Tanya (1997) "Quantifier Scope - How Labor is Divided between QR and Choice Functions." *Linguistics and Philosophy* 20, pp. 335-379. Winter, Yoad (1997) "Choice Functions and the Scopal Semantics of Indefinites." *Linguistics and Philosophy* 20, pp. 399-467. Kratzer, Angelika (1998) "Scope or Pseudoscope? Are there Wide-Scope Indefinites?" in S. Rothstein (ed.) *Events and Grammar*, Dordrecht: Kluwer, pp. 163 - 196. Matthewson, Lisa (1999) "On the Interpretation of Wide-Scope Indefinites," *Natural Language Semantics* 7.1

are encouraged to read these works, but for our current purposes here, all we want to point out is that, with respect to the behavior of indefinites, neither of the two theories we are trying to compare seems to have a special advantage over the other. This is because wide-Q readings result from DP-movement according to *both* theories.

As we mentioned earlier, a number of recent papers have been probing the connection between *de dicto* readings and the effects of Binding Condition C applying at LF. These authors have converged on the conclusion that DPs which are read as *de dicto* behave w.r.t. Binding Theory as if they are located below the relevant modal predicate at LF, and DPs that are read as *de re* (i.e., wide-Q, R-*de re*) behave as if they are located above. It is natural to inquire whether the same kind of evidence could also be exploited to determine the LF-location of the NP-part of a DP which is read as narrow-quantificational but restrictor-*de re*. If this acted for Condition C purposes as if it were below the attitude verb, it would confirm the standard theory (non-locally bound world-pronouns), whereas if it acted as if it was scoped out, we'd have evidence for the scopal account. Sharvit constructs some of the relevant examples and reports judgments that actually favor the scopal theory.[58] For example, she observes that (224a) does allow the narrow-Q, R-*de re*-reading indicated in (224b).

(224)   a.   How many students who like John$_1$ does he$_1$ think every professor talked to?
        b.   For which n does John think that every professor talked to n people in the set of students who actually like John?

More research is required to corroborate this finding.

As a final piece of potentially relevant data, consider a contrast recently discussed by Bhatt.[59]

(225)   [ji bai kican madhe ahe]$_i$ Ram-la watte ki [[t$_i$ [ti bai]$_i$] kican madhe nahi]
        REL woman kitchen in is Ram thinks that that woman kitchen in not is
        'Ram thinks that the woman who is in the kitchen is not in the kitchen'

(226)   Ram-la watte ki [[ji bai kican madhe ahe]$_i$ [[t$_i$ [ti bai]$_i$] kican madhe nahi]]
        Ram thinks that REL woman kitchen in is that woman kitchen in not is
        'Ram thinks that the woman who is in the kitchen is not in the kitchen'

The English translation of both examples has two readings: a (plausible) *de re* reading, on which Ram thinks of the woman who is actually in the kitchen that she isn't, and an (implausible) *de dicto* reading, on which Ram has the contradictory belief that he would express by saying: "the woman in the kitchen is not in the kitchen". The Hindi sentence (225) also allows these two readings,

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[58]Sharvit, Yael (1998) "*How-many* Questions and Attitude Verbs," ms. U. of Pennsylvania. (Sharvit's own conclusion, however, is not that her data supports the purely scopal theory.)

[59]Bhatt, Rajesh (1999) "Locality in apparently non-local relativization: Correlatives in the modern Indo-Aryan languages," handout for talk presented at UT Austin and MIT.

but (226) unambiguously expresses the implausible *de dicto* reading. Bhatt's explanation invokes the assumption that covert movement in Hindi cannot cross a finite clause boundary. In (225), where the correlative clause has moved overtly, it can stay high or else reconstruct at LF, thus yielding either reading. But in (226), where it has failed to move up overtly, it must also stay low at LF, and therefore can only be *de dicto*. What is interesting about this account is that it crucially relies on a scopal account of the R-*de re*-R-*de dicto* distinction. (Recall that with type-e DPs like definite descriptions, there *is* no additional wide/narrow-Q ambiguity.) If the standard theory with its non-locally bindable world-pronouns were correct, we would not expect the constraint that blocks covert movement in (226) to affect the possibility of a *de re* reading.

In sum, then, the evidence appears to be mixed. Some observations appear to favor the currently standard account, whereas others look like they might confirm the purely scopal account after all. Much more work is needed.[60]

7   Objects of Transitive Intensional Verbs

7.1   De re and De dicto readings

We have been assuming that sentences with transitive verbs and quantificational object DPs (type <et,t>) have LFs in which the object has been displaced from its surface position. We take the LF of (227) to be as in (228):

(227)   John broke three screwdrivers.

(228)   [$_{IP}$ [$_{DP}$ three screwdrivers] λ_1 [$_{IP}$ John [$_{VP}$ broke t$_1$]]]

Consider now in contrast:

(229)   John needs three screwdrivers.

This sentence appears to be syntactically analogous to (227), but displays an ambiguity that was absent from (227): it is ambiguous between a *de re* and a *de dicto* reading.[61] (229) can mean that there are three screwdrivers each of which John needs. (229) can also mean that John needs to have three screwdrivers, but there isn't necessarily any one screwdriver such that he needs that particular one. His need could be satisfied by any one of a lot of different sets of three screwdrivers.

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[60]Parallel issues arise with regard to temporal interpretation: Many authors have argued that the evaluation *time* for the restrictor of a quantificational DP is also not strictly determined by the scope of that DP with respect to temporal operators. See e.g. Enç, Mürvet (1981) *Tense without Scope: An Analysis of Nouns a Indexicals*, Ph.D. thesis, Univ. of Wisconsin, Madison; Musan, Renate (1995) *On the Temporal Interpretation of Noun Phrases*, Ph.D. thesis M.I.T. [also Garland Press 1997]; and Kusumoto, Kiyomi (1999) *Tense in Embedded Contexts*, Ph.D. thesis, Univ. of Massachusetts, Amherst, (especially chapter 2); and references cited there.

[61]In this section, we fall back into standard terminology and use "de re" for readings that wide-quantification and restrictor-*de re* and "de dicto" for those that are narrow-Q and R-*de dicto*, ignoring the possible existence of a third (narrow-Q and R-*de re*) reading.

There are transitive other verbs that give rise to the same sort of *de dicto* reading for their objects: *require, want, look for, wait for, lack*. We will restrict ourselves to *need* for the time being.

The only LF we can give at this point for (229) is of exactly the same form as (228):

(230) $[_{IP}\ [_{DP}\ \text{three screwdrivers}]\ \lambda_1\ [_{IP}\ \text{John}\ [_{VP}\ \text{needs}\ t_1]]]$

An appropriate lexical entry for *need* would seem to be the following:

(231) $[\![need]\!]^w = \lambda x.\lambda y.[y\ \text{needs}\ x\ \text{in}\ w]$

If we care to, we can do some lexical semantics and replace 'need' in the metalanguage with a more explicit definition, bringing out the modal character of the concept:

(232) $[\![need]\!]^w$
       $= \lambda x.\lambda y.[\text{all worlds w' s.t. all of y's needs in w are met in w' are s.t. y has x in w']}$
       $= \lambda x.\lambda y.\forall\ w'\ [w' \in R_{need,y}(w) \rightarrow y\ \text{has x in w']}$

Which reading do we get if we evaluate the LF in (230) by means of the entry (232)? We predict that the truth-conditions of this sentence are given by the following procedure: Examine the screwdrivers in w one by one, asking for each one whether John does or doesn't need that one (i.e. check whether John has that one in all worlds w' in which his needs in w are met). When we have found three for which the answer is 'yes', we have shown that (230) is true in w. Evidently, this amounts to the *de re* reading.

Then how can we account for the *de dicto* reading? One might hope at first that this could be accommodated simply by assigning a second reading to the verb *need*. But what could it be? We can easily persuade ourselves that it couldn't be *any* relation between individuals, i.e. no denotation of type <e,et> will do. Any such relation is one that people bear to particular entities, such as this screwdriver here, that pencil there, or perhaps that group of three screwdrivers over there. The intuitive point about the *de dicto* reading, however, is that (229) could be true under this reading even when it makes no sense to ask *which* screwdriver or group of screwdrivers John needs. It is not just that the speaker is deliberately vague about which screwdrivers John needs. Rather, under the *de dicto* reading, there is simply no fact of the matter: there *is* no particular screwdriver that John needs. One cannot break or paint or use a screwdriver without there being some particular screwdriver that one breaks or paints or uses. But one can apparently *need* a screwdriver without there being one that one needs. Needing in this sense is not a relation one bears to individuals. So what is going on?

7.2   A Biclausal Paraphrase and Its Analysis

An important first step towards an analysis of the *de dicto* reading is the realization that we get the same choice of readings in the following sentence:

(233)   John needs to have three screwdrivers.

The analysis of (233) is relatively unproblematic. We have something like the following surface structure:

(234)   John$_1$ needs [t$_1$ to have three screwdrivers]

From this we can get two LFs:

(235)   [three screwdrivers] λ_2 [e needs [John to have t$_2$]]

(236)   e needs [[three screwdrivers] λ_2 [John to have t$_2$]]

To interpret these LFs, we treat *need* as a necessity operator and assume that the contextually supplied accessibility relation is something like this:

(237) $\lambda w.\lambda w'$. John's needs in w are met in w'

(236) now is predicted to be true iff every world w' in which John's needs in w are met is such that there are three screwdrivers in w' that he has in w'. These can be different screwdrivers in different worlds w', so this adequately represents the *de dicto* reading. (235) on the other hand says that there are three screwdrivers in w such that John has them in every world where his needs are met. This is a *de re* reading.

7.3   A Syntactic Decompositional Treatment of Transitive Need

The discussion of the *need to have* sentence has shown that, as far as the biclausal (233) is concerned, the *de re-de dicto* ambiguity is easily tractable in the familiar way as a scope ambiguity. But how does this help us with the *de dicto* reading of the mono-clausal *John needs three screwdrivers*?

We could say that the problematic sentence is syntactically of the same structure as (233). We might posit an abstract phonologically inert verb with much of the same meaning as *have*. If you place that in the structure in (234) you would get something that sounds like *John needs three screwdrivers*. There will have to be some stories about how the object DP gets case, but that's what syntacticians are good at. Semantic interpretation then poses no special problems: the lexical entry for *need* that we need is just the one we used for (233). The ambiguity is a plain old scope ambiguity. Notice that we can completely eliminate the initial lexical entry in (232) now. It was an illusion when we thought there was

a transitive verb *need*. The specific reading comes out automatically when the object of the silent *have* is given widest scope.

Great, why not stop here? Well, for one we need to see how the account would be spelled out. The following readings contain some ideas on this topic.

McCawley, Jim: 1974 "On Identifying the Remains of Deceased Clauses." *Language Research 9*: 73-85.

den Dikken, Marcel, Richard Larson and Peter Ludlow: 1997a "Intensional "Transitive" Verbs and Concealed Complement Clauses." in P. Ludlow (ed.) *Readings in the Philosophy of Language*, Cambridge: MIT Press, pp. 1041 - 1053.

Larson, Richard, Marcel den Dikken and Peter Ludlow: 1997b "Intensional Transitive Verbs and Abstract Clausal Complementation." manuscript. SUNY Stony Brook. Available on Larson's homepage:
http://semlab2.sbs.sunysb.edu/Users/rlarson/itv.pdf

Of (more loosely) related interest:

Burton, Strang: 1995 *Six Issues to Consider in Choosing a Husband*, Rutgers Ph.D. thesis.

Further, however, there are at least two further approaches which rely on complicating the semantics, which is a manifestation of the usual problem that we can trade-off complexities between syntax and semantics. Since we want to learn how to adjudicate such situations, we should first sketch the semantic approaches. Then we can think about arguments that might decide between the various ways of getting the *de dicto* readings.

7.4　Montague's Treatment

Montague's idea was that transitive *need* takes as its object-argument not an individual, nor even a generalized quantifier of type <et,t>, but an intensional generalized quantifier of type <s,<et,t>>. To manufacture such an entity, we can rely on the rule of Intensional Functional Application which will apply to the verb + quantifier combination. The Montagovian LF for the non-specific reading and his lexical entry for *need* are these:

(238)　John needs three screwdrivers.
　　　　(= isomorphic to surface structure – object DP has stayed in situ!)

(239)　$[\![need]\!]^w = \lambda\wp_{<s,<et,t>>}.\lambda x \, \forall w' \, [w' \in R_{need,x}(w) \to \wp(w')(h(w')(x))=1]$,
　　　　where $h := \lambda w.\lambda x.\lambda y.[x \text{ has } y \text{ in } w]$

In appreciating what (239) does, it is helpful to recognize that the function h used here expresses essentially the (intension of the) passive of *have*.

Exercise 24

Work out the meaning of (238).

What's going on? The analysis says that John needs the intensional quantifier expressed by *three screwdrivers* iff in all of his need-worlds w' the value of applying the intensional quantifier to w' and applying the result to the concept of being-had-by-John-in-w' is 1. In a way, this analysis does *exactly* the same thing as the abstract syntactic account. It just does it all internal to the semantics. The price here is not abstract syntax, but powerful semantics; in particular, very complex meanings for lexical items like *need*.

Montague, Richard: 1973 "The Proper Treatment of Quantification in Ordinary English"

Zimmermann, Thomas Ede: 1993 "On the Proper Treatment of Opacity in Certain Verbs," *Natural Language Semantics* 1, pp. 149 - 179.

Moltmann, Friederike: 1995 "Intensional Verbs and Quantifiers," *Natural Language Semantics* 5, pp. 1 - 52.

7.5   The Problem of Decreasing Quantifiers

Moltmann (1995) discusses a class of examples that is problematic at first glance to both approaches that we have discussed, the syntactic decomposition approach and Montague's analysis. Consider:

(240)   a.   John needs no assistant.
        b.   John needs to have no assistant.

These sentences seem far from equivalent. (240a) conveys that John has no need for an assistant, he will do very well -thank you very much - without an assistant. He may not mind at all having an assistant - he just doesn't *need* one. (240b) on the other hand conveys that it is essential that John has no assistant. If he had one, things wouldn't work out. Therefore, (240b) is a much stronger statement.

————————

Question: Does (240b) entail (240a)?

————————

Moltmann takes this contrast as a conclusive argument against any account that would make the two structures in (240) essentially equivalent. Her analysis is something like this: the clausal complement structure gets an analysis along the lines suggested above, but the transitive object structure gets a special analysis that does not reduce (either in abstract syntax or in semantics) to the clausal case. Her analysis is something like the following (we won't go into details, since that would involve many complications):

(241)   John needs three screwdrivers/no assistant is true in a world w iff
        every minimal situation s in which John's needs in w are satisfied is
        such that he has three screwdrivers/no assistant in s.

The crucial trick here is the reference to "minimal situations".

Moltmann's analysis therefore is one in which the clausal complement structure and the transitive object structure get radically different semantic treatments - surely not the way to go if we can avoid it.

There is another way. We could claim that *no assistant* decomposes into negation and an indefinite *an assistant*. Further, we could say that the negation raises to above *need*. We would end up with a structure that would be equivalent to *John doesn't need an assistant*, which will unproblematically mean the same as *John doesn't need to have an assistant*.

In fact, it is not the case that the structures in (240) are really unambiguous. Consider the following:

(242)   a.   For once in his life, John needs no kids in his house, so he can finish the woodwork.
        b.   I NEED to have no assistant, I just really want one.

With some work, both structures can be made to assume the kind of meaning that in (240) was expressed by the other.

Perhaps, the reason that the clausal complement structure prefers a reading where negation takes scope under *need* is that negation doesn't like to raise over overt material. And perhaps, the reason that the transitive object structure prefers a reading where negation takes scope *above need* is that negation doesn't have far to raise.

An argument for this negation-splitting analysis comes from judgments about configurations where negation is prevented from raising for independent reasons. Consider:

(243)   a.   What I need is no assistants.
        b.   What I need to have is no assistants.
        c.   What I need is to have no assistants.

These sentence all unambiguously convey the reading where negation takes narrow scope: what is needed is the absence of assistants (instead of conveying that the presence of assistants is not needed). Moltmann's analysis would not know what to do with the fact that (243) does not have her "minimal situations" reading.

Below are some references on negation splitting.

Jacobs, Joachim: 1980 "Lexical Decomposition in Montague Grammar," *Theoretical Linguistics* 7

Jacobs, Joachim: 1991 "Negation," in D. Wunderlich & A.von Stechow (eds.) *Semantics: An International Handbook of Contemporary Research*, Berlin: de Gruyter

Rullmann, Hotze: 1995 "Geen eenheid," *Tabu* 25

de Swart, Henriette: 2000 "Scope Ambiguities with Negative Quantifiers," in K. von Heusinger & U. Egli (eds.) *Reference and Anaphoric Relations*, Kluwer: Dordrecht, pp. 109 – 132.

8   Tense in embedded clauses

8.1   Tenseless complement clauses

What happens to the time-argument of the verb in a tenseless clause? Consider ECM complements to verbs of believing:

(244)   John believed it to be raining.

Evidently, the time-argument of *raining* does not remain free and refer to the utterance time. Something seems to bind it. What?

Proposal 1: the higher tense
Proposal 2: the attitude verb

8.1.1   Proposal 1

On this view, (244) amounts to (245).

(245)   *PAST John believe [rain]* is true when uttered at t_u in w_u iff
         $\exists t < t_u$ [John believes in w_u at t that it rains at t]

In other words: there is a past time t such that it is raining at t in all worlds which conform to what John believes at t.

Consider these four worlds:

w_u: rain at 4 am, John awake at 4 am
w_1: rain at 4 am, John awake at 5 am
w_2: rain at 5 am, John awake at 4 am
w_3: rain at 5 am, John awake at 5 am

Assume that in all four worlds, John wakes up, has no idea what time it is, hears a dripping noise, and says to himself "it's raining (now)".

Which worlds conform to what John believes at 4 am in w_u?
In which worlds is it raining at 4 am?
Are the former a subset of the latter?
No!

Consider a variant of the story. Everything is the same as above, except that John, when he wakes up, thinks it is 5 am and says to himself: "It was raining at 4 am."

Fact: Sentence (244) is not a true report of John's beliefs in w_u in this story. Why not? There is a description, viz. *4 am*, which in fact picks out the time of John's thinking, and under which he ascribes rain to that time.

Conclusion: Sentence (244) *unambiguously* means that there is a past time t such that John at t ascribes rain to t *under the description "now"*.

Proposal 1 does not capture this fact.

8.1.2   Proposal 2

Background references: David Lewis (1979b) "Attitudes *de dicto* and *de se*."

Gennaro Chierchia (1990) "Anaphora and Attitudes *de se*," in R. Bartsch et al. (eds.) *Semantics and Contextual Expression*, Dordrecht: Foris.

believe (and other attitude verbs, or perhaps the COMPs they select) binds not just the world variable of its complement, but also the time variable.

(246) $[\![believe]\!]^{w,t}(P)(x) = 1$ iff
      for every world w' and time t' such that
      for all that x can tell in w at t, x might be located in w' at t',
      P(w')(t') = 1.

On this analysis, (244) means essentially that John *located himself at a raining-time.* This is intuitively correct.

8.2   Tensed complement clauses

(247)   John believed that it was raining.

On the so-called "simultaneous reading", (247) is equivalent to (244).
On the so-called "(back-)shifted reading", (247) is equivalent to (248).

(248)   John believed it to have been raining.

Ogihara's analysis (following earlier work by Ladusaw, Abusch, and others): Embedded PAST in (247) optionally deletes at LF. If deletion takes place, the result is essentially the same as the LF of the tenseless clause in (244). *believe* then binds the time argument of *raining*. If deletion does not occur, *believe* binds the 'source-time' argument of the embedded PAST. So the back-shifted reading of (247) (as well as the only reading of (248)) are analyzed as saying that John located himself at a "post-rain" time.

It seems that an attitude verb with a clausal complement *must* bind a time variable in it. Imagine all of the following sentences to be spoken on April 2nd.

(249)   a.   There is snow on the ground on April 2nd. I suspected that on March 13th.
           There was snow on the ground on March 31st. I suspected that on March 13th.
           There will be snow on the ground on May 1st. I suspected that on March 13th.
     b.   *I suspected on March 13th that there is snow on the ground on April 2nd.
           I suspected on March 13th that there was snow on the ground on March 31st.
           I suspected on March 13th that there will be snow on the ground on May 1st.

Here are some further data that show the need for past-tense deletion and tell us something about the environments that trigger it:

(250)   (Baker, C.L. (1989) *English Syntax*, MIT Press, p. 456)
    a.   Phyllis wants to tell Arthur, "John doesn't think that he will ever find out whether anyone knows when his baggage will arrive."
    b.   Phyllis wants to tell Arthur that John doesn't think that he will ever find out whether anyone knows when his baggage will arrive.
    c.   Phyllis want*ed* to tell Arthur, "John doesn't think that he will ever find out whether anyone knows when his baggage will arrive."
    d.   Phyllis wanted to tell Arthur that John didn't think that he would ever find out whether anyone knew when his baggage would arrive.

(251)   George seems to *have* thought that Bill would win the competition. (Baker, p. 457)

(252)   This contradicts John's *earlier* claim that he would be in Israel.

(253)   This contradicts John's claim that he would be in Israel.

(254)   You are accused of saying that you would tear down the temple and rebuild it in three days.

(255)   He is best remembered for predicting that no computer program would ever beat him at chess.

(256)- (258) are especially challenging for theories that try to give every past-tense a semantic interpretation. The reason is that they contain past tense in clauses whose event-time is not prior either to the speech time or to any other time mentioned or suggested elsewhere in the sentence.

(256)   I told Bill that you would say that you only had three magic tricks to do,....
    (Baker, cited by Ogihara)

(257)   (A week ago,) John decided that (10 days later at breakfast) he would tell his mother that they were having their last meal together. (Abusch)

(258)   John thought he would buy a fish that was still alive. (Ogihara)

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