

An Approach to Tense and Aspect in Minimal Recursion Semantics

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Arts

University of Washington
2005

Program Authorized to Offer Degree
Linguistics

University of Washington
Graduate School

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DEDICATION

To Cora, Henry and Simon

1 INTRODUCTION

Minimal Recursion Semantics (MRS) (Copestake et al, in press) is an approach to semantic representations, intended for use in computational systems. Its goals include expressive adequacy and computational efficiency. Copestake et al argue for a relatively sparse representation of tense, and have no account of aspect. This thesis is an examination of how tense and aspect may best be represented in MRS. In the process, it argues for a somewhat more elaborate representation than that put forward by Copestake et al. Although much of the argumentation uses examples from English, it is also informed by other languages, and attempts to arrive at an approach that will suffice for the tense and aspect phenomena found in languages throughout the world.

This thesis is divided into five main sections. The first lays out the particulars of MRS, which will be necessary in order to follow the proposals in the other two sections. Copestake et al's presentation of MRS leaves an acknowledged gap: the quantification of event variables. The second section tries to fill that gap. The third section lays out a new method of interpreting MRS structures – one that is explicit enough so that the proposals I make elsewhere in the thesis may be meaningfully evaluated. The fourth section examines a range of tense phenomena, drawn largely from Comrie (1985), arriving at an overall approach to tense in MRS. The fifth section similarly puts forward an approach to aspect, largely motivated by data and analysis drawn from Comrie (1976).

This thesis is not intended to be an in-depth account of the interface between syntactic representations and MRS representations. That is, while it is crucial that the MRS representations be relatable to the syntactic representations of the corresponding sentences, I do not go into the details here. This is left for future work.

2 MINIMAL RECURSION SEMANTICS

2.1 *Background*

Minimal Recursion Semantics (MRS) (Copestake et al in press) is an approach to representing the semantics of natural language. This brief description adds nothing to the more complete introduction in the paper just cited, but I include it here as necessary background in order to follow the following sections. The way MRS works is that every well-formed syntactic analysis of a natural language sentence is paired with an MRS representation. Standardly, it is assumed that the semantics of MRS representations are determined by relating them to expressions of some logical language, which are in turn assumed to have a well-defined semantics. Although in this section and elsewhere I use expressions of this language to clarify issues such as scope, see section 4 where I lay out a direct method of interpreting MRS structures.

MRS is intended to for use with computational grammars and thus its goals include not just expressive adequacy but computational efficiency. Thus, there is motivation for its representations to be as compact as is practical. One consequence of this is that it is sufficient (indeed, desirable) for MRS to have an abbreviated notation for any given distinction, as long as there is enough information for a later interpretation step to construct the fully elaborated version. A related consequence is that certain semantic distinctions (notably scope relations) are left underspecified, leaving the interpretive component to resolve them into multiple fully-resolved expressions. On the other hand, any semantic distinction that is dependent upon a distinction in the syntactic form must be explicitly represented.

2.2 *Elementary Predications*

MRS representations are based on *elementary predications* (EPs). An EP contains a relation and a list of variables. Each EP is labeled by a *handle*. An example is found in (1).

$$(1) \quad h1:\text{dog}(x)$$

Here, the relation is *dog* and *x* is a variable. The intuitive idea is that it is being predicated of *x* that it is a dog. This EP is labeled with the handle *h1*.

A single handle can label more than one EP, as in (2), which I will also write as (3). A bag of EPs with the same label is called an *EP conjunction*.

$$(2) \quad h1:\text{dog}(x), h1:\text{white}(x)$$

$$(3) \quad h1:\text{dog}(x) \wedge \text{white}(x)$$

The heart of an MRS representation is made up of a bag of EPs.

2.3 Quantification

Along with ordinary variables, which correspond to non-scopal arguments, an EP may contain a list of handles, which correspond to scopal arguments. For instance, quantification is handled by generalized-quantifier relations with three arguments: the bound variable, the handle which labels the EP conjunction of the quantifier's restriction, and the handle which labels the EP conjunction of the quantifier's nuclear scope.¹ Thus (4) is a (simplified) MRS representation of sentence (5):

- (4) Every white dog barks.
 (5) $\{h1:\text{every}(x, h2, h3), h2:\text{dog}(x) \wedge \text{white}(x), h3:\text{bark}(x)\}$

We can see the scope relationships a bit more clearly by translating this into a higher-order logical language. To do so, we just have to replace the handles in scopal relations with the EPs they label. For instance, the translation of (5) is (6).

- (6) $\text{every}(x, \text{dog}(x) \wedge \text{white}(x), \text{bark}(x))$

This is why MRS is considered a *flat* semantics. Its representation considers all EPs to be on the same level, whereas the corresponding higher-order expression contains levels of nesting.

2.4 Underspecification of Scope

Above it is mentioned that (5) is a simplified representation for the sentence (4). One of the ways it is simplified is that it has the scope relations fully specified. MRS, however, may leave scopal relations underspecified. This is done by disassociating the handles that label EPs from the handles that appear as scopal arguments. An example that contains a scope ambiguity is sentence (7), whose (still simplified) MRS is in (8).

- (7) Every dog chases some cat.
 (8) $\{h1:\text{every}(x, h2, h3), h4:\text{dog}(x), h5:\text{chases}(x, y), h6:\text{some}(y, h7, h8), h9:\text{cat}(y)\}$

MRS (8) corresponds to a set of fully scope-resolved expressions. This set contains every expression that can be formed by equating handle arguments with labels, subject to certain constraints. Specifically, every argument must be equated with some label, and no label may be equated with more than one argument. In addition, every ordinary (non-scopal) variable must be bound. That is, every occurrence of an ordinary variable must appear in an EP whose label is equated with an argument of either the EP where the variable appears as the bound variable, or an EP whose label appears as such an argument, and so on. Thus, the two possibilities for (8) are (9) and (10).

¹ In the MRS literature, the term *body* is used in place of *nuclear scope*, in order to reduce confusion with other uses of the word *scope*. From here on, I will do the same.

- (9) $\{h1:every(x, h4, h6), h4:dog(x), h5:chases(x, y), h6:some(y, h9, h5), h9:cat(y)\}$
 (10) $\{h1:every(x, h4, h5), h4:dog(x), h5:chases(x, y), h6:some(y, h9, h1), h9:cat(y)\}$

In (9), *every* has wide scope, so that for every dog, there may be a different cat it chases. In (10), *some* has wide scope, so that there is a single cat that every dog chases.

Quantifiers are not the only predicates that take handles as arguments. For instance, the predicate *probably* takes a handle as its argument. The handle argument is disassociated from any EP label, allowing it to participate in scope ambiguities as well. Sentence (11) has the MRS (12), with two scope-resolved variants (13) and (14).

- (11) Every dog probably barks.
 (12) $\{h1:every(x, h2, h3), h4:dog(x), h5:probably(h6), h7:bark(x)\}$
 (13) $\{h1:every(x, h4, h5), h4:dog(x), h5:probably(h7), h7:bark(x)\}$
 (14) $\{h1:every(x, h4, h7), h4:dog(x), h5:probably(h1), h7:bark(x)\}$

MRS (13) gives *every* wide scope, saying that for every dog, it is probably the case that that dog barks. MRS (14) gives *probably* wide scope, saying that it is probably the case that every dog barks.

2.5 Handle Constraints

It turns out that the general constraint mentioned above for equating handles with labels are not always sufficient to fully constrain the set of scope-resolved interpretations for an MRS. This is the case, for example, in sentence (15), whose (simplified) MRS appears in (16).

- (15) Every nephew of some famous politician runs
 (16) $\{h1:every(x, h2, h3), h4:nephew(x, y), h5:some(y, h6, h7), h8:famous(y) \wedge politician(y), h9:run(x)\}$

Without additional constraints, this could correspond to undesirable scopings such as (17) and (18).

- (17) $every(x, run(x), some(y, famous(y) \wedge politician(y), nephew(x, y)))$
 (18) $some(y, famous(y) \wedge politician(y), every(x, run(x), nephew(x, y)))$

In each of these interpretations, the *run* EP appears in the restriction of the *every* quantifier instead of its body. To avoid this, each MRS contains, in addition to the bag of EPs, a set of *handle constraints*. Mainly, these serve to specify which EPs must appear within the restrictions of which quantifiers. In addition an MRS contains a *top handle* which is constrained (via a handle constraint) essentially to correspond to the ultimate body of the sentence. The full MRS for sentence (15) appears as (19).

- (19) $\langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{nephew}(x, y), h5:\text{some}(y, h6, h7), h8:\text{famous}(y) \wedge \text{politician}(y), h9:\text{run}(x)\}, \{h0 =_q h9, h2 =_q h4, h6 =_q h8\} \rangle$

Thus, a full MRS representation consists of a triple: the top handle, the bag of EPs, and the set of handle constraints. The handle constraints are expressed as a set of pairs of handles related by the $=_q$ (pronounced *qeq*) relation. This constraint is satisfied if either the two handles are equal; or if the handle on the left is equal to the label of an EP whose ‘body’ argument is equal to the handle on the right; or if the handle on the left is equal to the label of an EP whose ‘body’ argument is equal to an EP whose ‘body’ argument is equal to the handle on the right; and so on. Thus, any number of quantifiers can “float” in between a handle and the label it is related to via $=_q$. Note that other handle-taking predicates, such as *probably*, do not have a ‘body’ argument, and thus cannot float in between such handles. These predicates are referred to as *fixed scopal predicates*.

2.6 Event Variables

The above MRS representations have been simplified in another way as well. Most work within the MRS framework assumes that verbs introduce neo-Davidsonian event variables. Thus, the MRS for sentence (13) is more properly given as in (14).²

- (20) Every dog barks.
 (21) $\langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{dog}(x), h5:\text{bark}(e, x)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$

The event variables are not explicitly bound. Copestake et al assume that a wide-scope quantifier for each event variable is implicit in the MRS, presumably to be inserted by the interpretive component. They acknowledge that this won’t always work, as there are cases where perhaps the scope of the event variable interacts with the scope of the explicit quantifiers. See below for a proposed revision of this.

2.7 Feature Structure Implementation

MRS was developed for use in computational grammars; in particular, grammars developed within a typed feature structure formalism. Thus, MRS structures are implemented as typed feature structures. The feature structure implementation used below is the one described in Flickinger et al (2003), and used by the LinGO Grammar Matrix (Bender et al, 2002), a framework for the development of broad-coverage, precision grammars for diverse languages. In this implementation, the EPs in (22a) and (23a) are implemented as in (22b) and (23b), respectively.

² For ease of exposition, I am taking the simplifying step of abstracting away from any representation of illocutionary force. My proposals should work as well in a system with them as in one without them.

(22) a. $h1:\text{dog}(x)$

b. $\left| \begin{array}{l} \textit{noun-rln} \\ \text{LBL} \quad h1 \\ \text{PRED} \quad _dog_rel \\ \text{ARG0} \quad x \end{array} \right|$

(23) a. $h2:\text{every}(x, h3, h4)$

b. $\left| \begin{array}{l} \textit{quant-rln} \\ \text{LBL} \quad h2 \\ \text{PRED} \quad _every_rel \\ \text{ARG0} \quad x \\ \text{RSTR} \quad h3 \\ \text{BODY} \quad h4 \end{array} \right|$

Each EP is implemented as a feature structure, whose type determines what sorts of arguments it may take. It has a feature for the handle that serves as its label, a feature for the predicate, and an additional feature for each argument. The values of each of these features are themselves typed feature structures. So the type of $h1$ would be *handle*, and the type of x would be *ref-ind* (for referential index).

The features appropriate for each type are specified in the definition for that type. For example, the definition of *noun-rln* specifies that it can take the features LBL, PRED and ARG0. It must take each of these features, and no others.

Types are arranged in a hierarchy, so that every type (except for the one at the top of the hierarchy) has one or more supertypes. Any feature specified as appropriate for a type will also be appropriate for its subtypes. The above relations would inherit from supertypes as shown in the following hierarchy fragment.

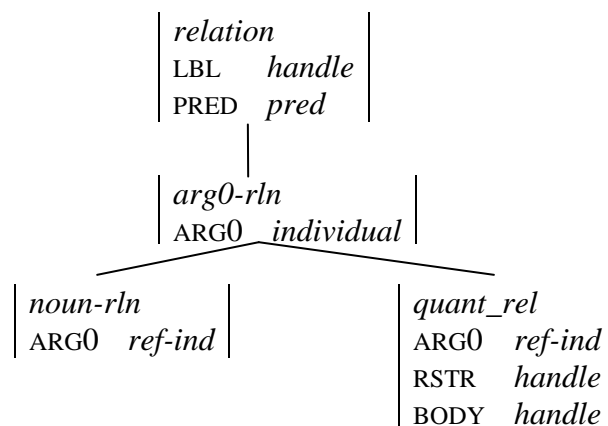


Figure 1: Type hierarchy for *noun-rln* and *quant_rel*

This type hierarchy specifies that any relation (i.e. any feature structure that instantiates a (sub)type of *relation*) will have the feature LBL, which takes a structure of type handle as its value, and the feature PRED, which takes a predicate as its value. One type of relation is *arg0-rln* (i.e. relations which take at least one argument), which takes the feature ARG0 in addition to LBL. The type *noun-rln* inherits from this type, and further specifies that the value of its ARG0 feature must be a referential index. Another type that inherits from *arg0-rln* is *quant_rel*, which is the supertype for any quantifying relation. In addition to the other features, this type takes RSTR and BODY.

2.8 Tense

Copetake et al analyze tense by setting the value of a TENSE feature on the verb's event variable. For instance, the MRS for (24) is given in (25).

(24) Every dog barked.

(25) $\langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{dog}(x), h5:\text{bark}(e[\text{TENSE past}], x)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$

The notation $e[\text{TENSE past}]$ is an attempt to indicate feature settings while keeping with the otherwise more readable linear notation.

Copetake et al acknowledge the possibility of perhaps more semantically interesting representations that include EPS like *hold(e, t)*, *precedes(t, now)*. But as they point out, this representation can be derived from the simpler one during the interpretive step. Unless some other part of the semantics requires the more elaborate structure, the goals of brevity and computational efficiency cause us to prefer the simpler representation.

3 QUANTIFICATION OF EVENT VARIABLES

As will be explained in more detail below, tense and aspect are concerned with the structure and properties of events. Before we can deal with this properly, we must be sure that we have a proper representation of events to begin with. Copestake et al (in press, section 6.1.2) acknowledge that their account of events as having an implicit wide-scope quantifier is not the end of the story. This section takes a closer look at the appropriate way to quantify events.

One possibility for event variables is the one assumed by Copestake et al, namely that there is an implicit wide-scope quantifier for each event variable. How does this play out when there are other quantified variables? Let's look at an example containing a universally quantified variable, as in (26).

(26) Every dog barked.

An MRS structure assuming a wide-scope (existential) quantifier for the event variable would be equivalent to the structure in (27).

(27) $\langle h0, \{h0:\text{exist}(e, h1), h2:\text{every}(x, h3, h4), h5:\text{dog}(x), h6:\text{bark}(e, x)\}, \{h1 =_q h6, h3 =_q h5\} \rangle$

Notice that the top handle is not just $=_q$ the label of the existential quantifier, it is equal to it. This forces the wide scope. Also notice that the *exist* relation is not a normal quantifier, in that it doesn't have a restriction and a body – it simply has a single scopal argument. A normal existential quantifier (i.e. *some*) says that there is at least one thing that meets the constraints in both its restriction and its body – an identical effect can be achieved by putting all the constraints into a single argument. The predicate *exist* says there is at least one thing that meets the constraints in its (handle) argument. I use *exist* here for two reasons. First, there is only one EP conjunction that provides constraints, so there aren't enough labels for two arguments. Second, *exist* is an implicit quantifier, so even if there were more than one EP involved, there would be no basis for determining which of them should go in the restriction and which should go in the body.

The higher-order logical expression corresponding to MRS (27) is given in (28).

(28) $\text{exist}(e, \text{every}(x, \text{dog}(x), \text{bark}(e, x)))$

This says that there is a single event such that for every dog that event is an event of that dog barking. Perhaps there is a reading of (26) where all the dogs participated in one collective bark, but surely the more salient reading is one where every dog had its own separate barking event.

So perhaps instead we should posit an implicit narrow-scope existential quantifier for events. Using this approach, the sentence in (29) would get (the equivalent of) the MRS representation in (30),³ which maps to the logical expression in (31).

- (29) Kim spoke to all the students.
 (30) $\langle h0, \{h1:\text{exist}(e, h6), h2:\text{every}(x, h3, h4), h5:\text{student}(x), h6:\text{speak_to}(e, \text{KIM}, x)\}, \{h0 =_q h1, h3 =_q h5\}\rangle$
 (31) $\text{every}(x, \text{student}(x), \text{exist}(e, \text{speak_to}(e, \text{KIM}, x)))$

Here, I've forced the narrow scope of the existential quantifier by making the scopal argument of the existential quantifier equal (not just $=_q$) to the *speak_to* relation, and the top handle $=_q$ to the label of the existential quantifier. But now, (31) means that there is a separate event for each student. One reading of (29) has Kim speaking to all the students as a group. This requires there being a single event, indicating that the existential quantifier has to be allowed to take wide scope.

It seems as if the event quantifier must be fully involved in scopal relations. The proper representation for (29) should be something equivalent to (32).

- (32) $\langle h0, \{h1:\text{exist}(e, h2), h3:\text{every}(x, h4, h5), h6:\text{student}(x), h7:\text{speak_to}(e, \text{KIM}, x)\}, \{h0 =_q h1, h2 =_q h7, h4 =_q h6\}\rangle$

This allows the quantifier *every* to float above or below the quantifier *exist*.

Does this requirement that the event quantifier be allowed to participate fully in scopal relations entail that it be represented explicitly in the MRS? Not necessarily. The MRS in (32) is completely derivable from the simpler MRS in (33) Just add the *exist* EP, making the top handle $=_q$ to its label, and making its handle argument $=_q$ to whatever the top handle had been $=_q$ to.

- (33) $\langle h0, \{h3:\text{every}(x, h4, h5), h6:\text{student}(x), h7:\text{speak_to}(e, \text{KIM}, x)\}, \{h0 =_q h7, h4 =_q h6\}\rangle$

Thus, the implicit *exist* would behave as a fixed scopal EP (cf. the discussion of *probably* above). This is appropriate: fixed scopal predicates don't have restriction and body arguments and neither does *exist*. Furthermore, I am unaware of any case where it makes sense to have an event quantifier appear between a quantifier and its restriction.

Assuming the implicit *exist* quantifier is a fixed scopal EP also predicts that it cannot float between other fixed scopal EPs. We can consider these two examples, using the scopal predicates *probably* and *not*, respectively.

³ Throughout this thesis I am abstracting away from the issue of quantification for proper nouns and definite descriptions, as that issue is orthogonal to the ones I am considering here.

- (34) Kim didn't speak to all the students.
 (35) $\langle h0, \{h1:\text{not}(h2), h3:\text{every}(x, h4, h5), h6:\text{student}(x), h7:\text{speak_to}(e, \text{KIM}, x)\}, \{h0 =_q h1, h2 =_q h7, h4 =_q h6\}\rangle$
 (36) Kim probably spoke to all the students.
 (37) $\langle h0, \{h1:\text{probably}(h2), h3:\text{every}(x, h4, h5), h6:\text{student}(x), h7:\text{speak_to}(e, \text{KIM}, x)\}, \{h0 =_q h1, h2 =_q h7, h4 =_q h6\}\rangle$

If in either of these cases, there is both a reading where the event quantifier appears between $h0$ and $h1$ and a reading where it appears between $h2$ and $h7$, then it must be a normal floating quantifier. But in both these cases, there are only readings where the scopal predicates outscope the event quantifier, and not the other way around. That is, we do not find readings such as (38) or (39). We just get readings such as (40) and (41).

- (38) $\text{exist}(e, \text{every}(x, \text{student}(x), \text{not}(\text{speak_to}(e, \text{KIM}, x))))$
 (39) $\text{every}(x, \text{student}(x), \text{exist}(e, \text{not}(\text{speak_to}(e, \text{KIM}, x))))$
 (40) $\text{not}(\text{exist}(e, \text{every}(x, \text{student}(x), \text{speak_to}(e, \text{KIM}, x))))$
 (41) $\text{every}(x, \text{student}(x), \text{not}(\text{exist}(e, \text{speak_to}(e, \text{KIM}, x))))$

In (38), there is a single event such that for every student it is not the case that it is an event of Kim speaking to that student. In (39), for every student there is some event which is not an event of Kim speaking to that student. Neither of these is what (34) means.

The rule for deriving a version of the MRS with an explicit event quantifier from the version that leaves it implicit, then, is to insert it at the bottom of the chain of fixed-scopal EPs. That is, add the *exist* EP to the MRS, and make its argument $=_q$ the EP with the event it is quantifying. Then make whatever handle that *was* $=_q$ to the event EP $=_q$ to the *exist* EP instead.

And since such a rule can be stated which can always derive the proper explicitly-quantified MRS from the implicitly-quantified one, we can do without the explicit quantifier in the representation and leave it implicit.

4 THE SEMANTICS OF MRS

Copestake et al (in press) characterize the semantics of MRS structures indirectly, by relating them to expressions of a logical language. The expressions of this language are to be interpreted to get the final model-theoretic meaning of the sentence. However, no formal semantic account of this language is given. Copestake et al (2001) go a bit further. The purpose of that paper is to present an algebra for composing the MRS structures of phrases from the MRS structures of their components; but they do include some rules for deriving model-theoretic interpretations for expressions of MRS. But these rules become vague when they are finally applied to the representations of full sentences with quantification. In this section I present my own account of the semantics of MRS structures, building upon pieces from Copestake et al (2001). It is novel, to my knowledge, in that it doesn't deal with intensional contexts using possible worlds. Rather, it stores hypotheses in the model, and these hypotheses can participate in other relations.

4.1 Simple Semantic Entities

In the process of explaining the structure of MRS, Copestake et al (2001) introduce the idea of a 'simple elementary predication' (SEP). This consists of two components: a predicate symbol and a list of zero or more ordinary variable arguments of the relation. These are just the EPS as described above, but without labels or scopal arguments.

They then define a 'Simple MRS' (SMRS) as (either the absurdity symbol \perp or) an ordered pair consisting of a bag of SEPs and a set of equalities between variables. An example is found in (42).

- (42) a. Kim sleeps.
 b. $\langle \{sleep(e_1, x_1), r_name(x_2, Kim)\}, \{x_1 = x_2\} \rangle$

An SMRS is interpreted with respect to a model $\langle E, A, F \rangle$ where E is a set of events, A is a set of individuals, and F is an interpretation function, assigning relations to predicate symbols. The truth definition contains these four clauses, where M is the model and g is a function which assigns individuals to variables:

- 1 For all events and individuals v , $[[v]]^{(M, g)} = g(v)$.
- 2 For all n -predicates P^n , $[[P^n]]^{(M, g)} = F(P^n)$.
- 3 $[[P^n(v_1, \dots, v_n)]]^{(M, g)} = 1$ iff $\langle [[v_1]]^{(M, g)}, \dots, [[v_n]]^{(M, g)} \rangle \in [[P^n]]^{(M, g)}$.
- 4 $[[\phi \wedge \psi]]^{(M, g)} = 1$ iff $[[\phi]]^{(M, g)} = 1$ and $[[\psi]]^{(M, g)} = 1$.⁴

The denotation of an SMRS with respect to a model can be thought of as a set of variable assignment functions; those with respect to which the denotation of the SMRS is 1. So the denotation of the SMRS (42b) is the set of variable assignments that assign an

⁴ The SEPs in an SMRS are implicitly conjoined

event to e_1 and an individual to $x_1 (= x_2)$ such that the individual is named Kim and the event is an event of that individual sleeping.

4.2 Interpretation of Scopal Relationships

What we have seen so far doesn't tell us how to tell when a sentence is true with respect to a model. There is no account yet of quantification in an SMRS and no semantic account of what to do with it. In standard approaches, all variables in a sentence are quantified, so we can define truth with respect to a model and an arbitrary assignment function g by specifying a g' within the scope of a quantifier that specifies a particular value for the bound variable.

Copestake et al (2001) introduce quantification as we have seen above in section 2. So EPS are expanded to include handles as their labels and scopal arguments which are filled by handles. Handles and labels are associated via $=_q$ handle conditions. We still don't have a traditional notion of quantification: words like "every" are associated with predicates rather than quantifiers (Copestake et al, 2001, footnote 5). They have this to say about what the new truth definition looks like (page 6): "The truth definition for [MRSS] is analogous to before. We add to the model a set of labels L (handles denote these via g) and a well-founded partial order \leq on L (this helps interpret the [handle conditions])."

They note as advantages that the MRS language is first-order, and the semantics does not use λ -abstraction over higher order elements, such as an expression like $\lambda P \lambda Q \forall x (P(x), Q(x))$. I could also add that it allows us to model the semantics of scopal predicates without using intensional logic. That is we have a straightforward account for sentences like (43), with an MRS like (44).

- (43) Kim probably sleeps.
 (44) $\langle h_0, \{h_0:\text{probably}(h_1), h_1:\text{sleep}(\text{KIM})\} \rangle$

Here I've abstracted away from any variable equalities and handle constraints so as to deal with a fully scope-resolved MRS. (Presumably this allows us to do without the partial order \leq in the model.) Also for now I've abstracted away from issues of free variables and quantification (although we'll come back to that below).

We've added a set of labels L to the model. I assume they are used as an additional argument in the denotation of each predicate, rendering, for example, $[[\text{sleep}]]$ as a set of tuples of the form $\langle \text{label}, \text{individual} \rangle$. $[[\text{probably}]]$ would be a relation from labels to labels. Any assignment function in the denotation of MRS (44) would have to have an entry in the *probably* relation where the second argument (the label that stands in for the thing that is probable) is also the label for the entry in the *sleep* relation where Kim is the sleeper.

But how does this play out for a sentence with quantifiers, like (26), repeated here as (45), even abstracting away from event variables?

- (45) Every dog barked.
 (46) $\langle h0, \{h0:\text{every}(x, h1, h2), h1:\text{dog}(x), h2:\text{barked}(x)\} \rangle$

The denotation for MRS (46), becomes the set of assignments that assign values to $h0$, $h1$, $h2$ and x such that $\langle [[h0]]^{(M, g)}, [[x]]^{(M, g)}, [[h1]]^{(M, g)}, [[h2]]^{(M, g)} \rangle \in [[\text{every}]]^{(M, g)}$, $\langle [[h1]]^{(M, g)}, [[x]]^{(M, g)} \rangle \in [[\text{dog}]]^{(M, g)}$ and $\langle [[h2]]^{(M, g)}, [[x]]^{(M, g)} \rangle \in [[\text{barked}]]^{(M, g)}$. But this seems to have brought us back a step, not forward. Not only are we still left with a set of assignment functions as a denotation rather than a truth value, but it's hard to even see how this denotation has much to do with the meaning of (45). It looks as though all the assignments in $[[46]]$ must assign x to a dog who barked, but that's about as far as it goes. Two problems in particular with this denotation are 1) the denotation of *every* can vary from model to model; 2) Sentence (45) doesn't entail sentence (47). That is there may be assignments in $[[46]]$ that are not in $[[48]]$.

- (47) Every white dog barked.
 (48) $\langle h0, \{h0:\text{every}(x, h1, h2), h1:\text{dog}(x) \wedge \text{white}(x), h2:\text{barked}(x)\} \rangle$

Imagine a model that looked like this: $[[\text{dog}]]^M = \{\langle H_1, \text{FIDO} \rangle, \langle H_2, \text{SPOT} \rangle\}$;
 $[[\text{bark}]]^M = \{\langle H_3, \text{FIDO} \rangle, \langle H_4, \text{SPOT} \rangle\}$; $[[\text{white}]]^M = \{\langle H_3, \text{FIDO} \rangle\}$;
 $[[\text{every}]]^M = \{\langle H_5, \text{SPOT}, H_2, H_4 \rangle\}$. In a model like this, the assignment $\{h0 \rightarrow H_5, h1 \rightarrow H_4, h2 \rightarrow H_3, x \rightarrow \text{SPOT}\}$ will make $[[46]] = 1$, but $[[48]] = 0$.

It appears that the Copestake et al approach is unsatisfactory. But I will propose here an approach along the same broad outlines that is satisfactory. That is, I will present a semantic account of the first order MRS language, without using higher order lambda extraction, that avoids the use of intensional logic in dealing with scopal predicates, but will still make the correct entailment predictions for sentences with normal quantification.

4.3 Models

The MRSS are interpreted with respect to a first order model $\langle E, A, H, K, X, F, R \rangle$ where:

- E is a set of events
- A is a set of individuals
- H is a set of hypothesis labels (or simply hypotheses)
- K is a set of kinds⁵
- X is a relation between kinds and hypotheses
- C is a function from sets of hypothesis labels to hypothesis labels
- F is an interpretation function, which assigns relations to the predicates of the language.
- R is a subset of H , the set of hypotheses that correspond to actual situations

⁵ The use of the term *kind* is intended to evoke the idea of kinds as used in Carlson (1977)

Each relation in F is made up of tuples whose elements are drawn from E , A , H , and K . Each relation is typed, in the sense that each field in the tuple can be filled by an element from exactly one of these sets. The exception is that any field that draws its filler from E or A can also be filled with a kind.

The first field in each tuple of every relation is a hypothesis label, and that label is a *key* to that relation. That is, no label may appear as the first element of more than one tuple in the relation. In fact, hypothesis labels are more than just keys to each relation: no label appears as the first element of more than one tuple anywhere in the model.

For each relation whose tuples may contain individuals, a tuple appears for every possible combination of individuals. The set R contains the hypothesis labels of the tuples that correspond to facts that actually obtain in the world. Any two models that have the same universe of events and individuals will have identical F functions. The only thing that distinguishes these models is R .

When a kind appears in a tuple, it may either be a *definitional* appearance or a normal appearance. The relation X relates kinds to the hypotheses that define them. (A kind may be defined by more than one hypothesis.) Definitional tuples serve only to define kinds; there is no sense in which they actually obtain as facts in the world. Thus, No definitional hypothesis may appear in R .

The function C takes a set of hypothesis labels and returns the label of the hypothesis that corresponds to the conjunction of the input hypotheses. For any singleton set, this function will return the single element in that set.

Figure 2 contains an example model.

$E = \{E_1, E_2, E_3, \dots\}$ $A = \{\text{FIDO, SPOT, FELIX}\}$ $L = \{H_0, H_1, H_2, \dots\}$ $K = \{K_1, K_2, K_3, \dots\}$ $X = \{\langle K_1, H_3 \rangle, \langle K_2, H_4 \rangle, \langle K_2, H_{13} \rangle, \langle K_3, H_8 \rangle, \langle K_4, H_9 \rangle, \langle K_4, H_{14} \rangle, \langle K_5, H_{19} \rangle\}$ $C = \{\langle \{H_0\}, H_0 \rangle, \langle \{H_1\}, H_1 \rangle, \langle \{H_0, H_{10}\}, H_{20} \rangle, \dots\}$	$F = \left\{ \begin{array}{l} \text{cat} \rightarrow \{\langle H_0, \text{FIDO} \rangle, \langle H_1, \text{SPOT} \rangle, \langle H_2, \text{FELIX} \rangle, \langle H_3, K_1 \rangle, \langle H_4, K_2 \rangle, \dots\} \\ \text{dog} \rightarrow \{\langle H_5, \text{FIDO} \rangle, \langle H_6, \text{SPOT} \rangle, \langle H_7, \text{FELIX} \rangle, \langle H_8, K_3 \rangle, \langle H_9, K_4 \rangle, \dots\} \\ \text{big} \rightarrow \{\langle H_{10}, \text{FIDO} \rangle, \langle H_{11}, \text{SPOT} \rangle, \langle H_{12}, \text{FELIX} \rangle, \langle H_{13}, K_2 \rangle, \langle H_{14}, K_4 \rangle, \dots\} \\ \text{chase} \rightarrow \{\langle H_{15}, E_1, \text{FIDO, FIDO} \rangle, \langle H_{16}, E_2, \text{FIDO, SPOT} \rangle, \langle H_{17}, E_3, \text{FIDO, FELIX} \rangle, \\ \dots, \langle H_{18}, E_4, \text{SPOT, K}_2 \rangle, \dots, \langle H_{19}, E_5, \text{FIDO, K}_5 \rangle, \dots\} \end{array} \right.$
$R = \{H_2, H_5, H_6, H_{10}, H_{12}, H_{17}, H_{18}\}$	

Figure 2: A sample model

This model contains the individuals Fido, Spot and Felix. H_0 through H_2 are the hypotheses that Fido, Spot and Felix are cats, respectively, but only H_2 appears in R .

That is, only Felix actually is a cat. Similarly, Fido and Spot are dogs; Fido and Felix are big, and E_3 is an actual event of Fido chasing Felix.

There are also five kinds shown in this model fragment. (All possible kinds always appear in every model.) The set X says that the kind κ_1 is defined by H_3 , making it the kind “cats”. Similarly, κ_2 is the kind “big cats”, κ_3 is the kind “dogs”, κ_4 is “big dogs” and κ_5 is “things Fido chases”. Note that H_{18} , although it contains the type κ_2 , is not part of its definition. Rather, this is the hypothesis that Spot chases big cats. This hypothesis could appear in R , if, in this model, Spot actually does chase big cats.

The function C takes the set of hypotheses $\{H_0, H_{10}\}$ to the hypothesis H_{20} . This indicates that hypothesis H_{20} is the conjunction of H_0 and H_{10} ; that is, the hypothesis that Fido is a cat and that Fido is big. To put it another way, it is the hypothesis that Fido is a big cat.

4.4 Denotations (no Quantification)

The denotations of the components of MRS structures, excluding quantificational and other logical EPs, are assigned according to these rules:

- For all individual and event variables v , $[[v]]^{(M, g)} = g(v)$.
- For all predicates P , $[[P]]^{(M, g)} = F(P)$.
- For non-logical EPs $P(v_1, \dots, v_n)$, $[[P(v_1, \dots, v_n)]]^{(M, g)}$ = an ordered pair of the form $\langle h \in H, t \in \{0, 1\} \rangle$
 - $h = h \mid \langle h, [[v_1]]^{(M, g)}, \dots, [[v_n]]^{(M, g)} \rangle \in [[P]]^{(M, g)}$
 - $t = 1$ iff $h \in R$
- For all EP conjunctions $EPC = \{EP_1, \dots, EP_n\}$, $[[EPC]]^{(M, g)}$ = an ordered pair of the form $\langle w \in \text{POW}(H), t \in \{0, 1\} \rangle$
 - $w = \{h_1, \dots, h_n\}$ such that $[[EP_1]]^{(M, g)} = \langle h_1, t_1 \rangle, \dots, [[EP_n]]^{(M, g)} = \langle h_n, t_n \rangle$
 - $t = 1$ iff $\forall EP \in EPC, [[EP]]^{(M, g)} = \langle h, 1 \rangle$
- For all handles h , $[[h]]^{(M, g)} = C(x)$, where $[[\text{the EP labeled by } h]]^{(M, g)} = \langle x, \dots \rangle$
- A fully scope-resolved MRS is true if the second element of the denotation of its top handle is *true*.

The first of these rules says that the denotations of variables are determined by the assignment function g . The second just says that the denotation of a predicate is the relation associated with it through F .

The third says that the denotations of EPs have two parts. Intuitively, they correspond to the Fregean notions of sense and reference. The first part, which corresponds to the “sense”, is a hypothesis label. It is the hypothesis label that labels the tuple found in the appropriate relation, where each slot in the tuple is filled by the denotation of the corresponding argument in the EP. Since every combination of individuals appears in every relation, there is guaranteed to be such a hypothesis.

The other part of the denotation of an EP corresponds to its “reference”. It is a truth value. The EP is true if its sense is in R , and false otherwise.

The fourth rule tells how to build denotations of EP conjunctions from denotations of their component EPs. These denotations are also pairs of sense and reference. The sense is just the set whose members are the senses of the component EPs. The reference is a truth value: true if all the component EPs are true, false otherwise.

The fifth rule tells how to get the denotation of a handle: Take the sense element of the EP conjunction that the handle is the label of, and send that through the function C to get a single hypothesis as its value.

From here forward, I will use the notation $[[\alpha]]_{Sense}$ to refer to the sense element of $[[\alpha]]$ and the notation $[[\alpha]]_{Ref}$ to refer to the reference element of $[[\alpha]]$.

Let's look at a quantification-free example using just these rules. Figure 3 contains a model fragment.

$$\begin{array}{l}
 E = \{ \} \\
 A = \{ \text{FIDO} \} \\
 L = \{ H_0, H_1, \dots \} \\
 K = \{ \dots \} \\
 X = \{ \dots \} \\
 C = \{ \langle \{ H_0 \}, H_0 \rangle, \dots \} \\
 \\
 F = \left| \begin{array}{l} \textit{sleep} \rightarrow \quad \{ \langle H_0, \text{FIDO} \rangle, \dots \} \\ \textit{probably} \rightarrow \quad \{ \langle H_1, H_0 \rangle, \dots \} \end{array} \right| \\
 \\
 R = \{ H_1 \}
 \end{array}$$

Figure 3: Model for *Fido probably sleeps*

This model shows two hypotheses. H_0 is the hypothesis that Fido sleeps. H_1 is the hypothesis that it is probable that Fido sleeps. R tells us that although Fido probably sleeps, it is not the case that Fido actually sleeps.

Let's look at how we build the denotation for (50), which is the scope-resolved MRS for (49). (In order to put off issues related to quantification until later, I am glossing over the semantics of proper names and leaving out the event variable.)

- (49) Fido probably sleeps.
(50) $\langle h_0, \{ h_0:\textit{probably}(h_1), h_1:\textit{sleep}(\text{FIDO}) \} \rangle$

By assumption, $[[\text{FIDO}]]^{(M, g)} = \text{FIDO}$
 $[[\text{sleep}(\text{FIDO})]]^{(M, g)} = \langle [h \mid \langle h, \text{FIDO} \rangle \in F(\text{sleep})], 1 \text{ iff } [h \mid \langle h, \text{FIDO} \rangle \in F(\text{sleep})] \in R \rangle$
 $[[\text{sleep}(\text{FIDO})]]^{(M, g)} = \langle H_0, 0 \rangle$
 $[[h1:\text{sleep}(\text{FIDO})]]^{(M, g)} = \langle \{H_0\}, 0 \rangle$
 $[[h1]]^{(M, g)} = H_0$
 $[[\text{probably}(h1)]]^{(M, g)} = \langle [h \mid \langle h, H_0 \rangle \in F(\text{probably})], 1 \text{ iff } [h \mid \langle h, H_0 \rangle \in F(\text{probably})] \in R \rangle$
 $[[\text{probably}(h1)]]^{(M, g)} = \langle H_1, 1 \rangle$
 $[[h0]]^{(M, g)} = \langle \{H_1\}, 1 \rangle$
 MRS (50) is true

4.5 Denotations with Quantification

Quantificational EPS, that is, EPS whose predicate is one of an enumerable class including *every* and *some*, also have sense-reference pairs as their denotations. However, these are constructed a little differently. For these, you don't just look up the sense in the model and then see if it is in R to get the reference. You *do* look the sense up in the model, but you do it a bit differently. To get the reference, you don't look to see if the sense is in R ; you go through more conventional methods, using variable binding, with a slightly different set of rules for each quantifier.

Here are the rules for getting the reference for *every*, *some* and *exist*:⁶

- $[[\text{every}(x, h1, h2)]]^{(M, g)}_{Ref} = 1 \text{ iff } \forall u \in A \cup E [[h1]]^{(M, g[u/x])}_{Ref} \rightarrow [[h2]]^{(M, g[u/x])}_{Ref}$
- $[[\text{some}(x, h1, h2)]]^{(M, g)}_{Ref} = 1 \text{ iff } \exists u \in A \cup E [[h1]]^{(M, g[u/x])}_{Ref} \wedge [[h2]]^{(M, g[u/x])}_{Ref}$
- $[[\text{exist}(x, h1)]]^{(M, g)}_{Ref} = 1 \text{ iff } \exists u \in A \cup E [[h1]]^{(M, g[u/x])}_{Ref} = 1$

How do you get the sense of a quantifier EP? Like other kinds of EPS, the sense is a hypothesis label. Before getting into how we find this label for a given EP, let's look at how quantificational senses are stored in the model. Figure 4 contains an appropriate model fragment.

⁶ Of course, there are an infinite number of quantifiers of this sort, and they cannot all be given separate interpretation rules. I leave the task of describing the infinite class of generalized quantifiers with finite means for future work.

$$\begin{array}{l}
E = \{ \} \\
A = \{ \text{FIDO, SPOT} \} \\
L = \{ H_0, H_1, \dots \} \\
K = \{ K_0, K_1, \dots \} \\
X = \{ \langle K_0, H_2 \rangle, \langle K_1, H_5 \rangle, \dots \} \\
\\
F = \left\{ \begin{array}{l}
\textit{dog} \rightarrow \quad \{ \langle H_0, \text{FIDO} \rangle, \langle H_1, \text{SPOT} \rangle, \langle H_2, K_0 \rangle, \dots \} \\
\textit{sleep} \rightarrow \quad \{ \langle H_3, \text{FIDO} \rangle, \langle H_4, \text{SPOT} \rangle, \langle H_5, K_1 \rangle, \dots \} \\
\textit{every} \rightarrow \quad \{ \langle H_6, K_0, K_1 \rangle, \langle H_7, K_1, K_0 \rangle, \dots \} \\
\textit{probably} \rightarrow \quad \{ \langle H_8, H_3 \rangle, \langle H_9, H_4 \rangle, \langle H_{10}, H_6 \rangle, \langle H_{11}, H_7 \rangle, \dots \}
\end{array} \right. \\
\\
R = \{ H_0, H_1, H_3, H_8, H_9 \}
\end{array}$$

Figure 4: A model with quantification

In this model, there are two individuals: FIDO and SPOT. They are both (actually) dogs. FIDO sleeps, SPOT does not. Quantificational predicates are stored in the model as relations between kinds. There are two kinds shown: K_0 is *dogs* and K_1 is *sleepers*. The hypothesis H_6 is the hypothesis that all dogs are sleepers, i.e. that every dog sleeps. H_7 is the hypothesis that every sleeper is a dog. These hypotheses do not appear in R . Or if they did, it wouldn't have any effect: the only way to tell whether every dog actually sleeps is to follow the rule above for determining the reference of an *every* EP. On the other hand, these hypotheses can appear as arguments in the *probably* relation. Here, H_8 , for example, is the hypothesis that the hypothesis that FIDO sleeps is probable. In other words, H_8 is the hypothesis that FIDO probably sleeps. H_{10} is the hypothesis that it is probable that every dog sleeps.

Now that we see how quantifier senses are stored in the model, here are the rules for determining the sense of a quantifier EP. (The first is for quantifiers like *some* and *every*. The second is for quantifiers like *exist*.)

- For every quantificational EP $Q(x, h1, h2)$,
 $[[Q(x, h1, h2)]]^{(M, g)}_{\text{Sense}} = h \mid \langle h, \textit{kind}(h1, x), \textit{kind}(h2, x) \rangle \in [[Q]]^{(M, g)}$
- For every quantificational EP $Q(x, h1)$,
 $[[Q(x, h1)]]^{(M, g)}_{\text{Sense}} = h \mid \langle h, \textit{kind}(h1, x) \rangle \in [[Q]]^{(M, g)}$

The idea behind these definitions is that the EP conjunctions labeled by the handle arguments in a quantificational EP, together with the bound variable, are enough to uniquely determine a kind. The function *kind* is the one that takes an EP conjunction and a variable and returns a kind, if possible. Here is a description of what *kind* does with an EP conjunction *ec* and the variable *x*.

For each EP ep_i in *ec*, get $\textit{kinds}_i = \{ k \in K \mid \langle k, [[ep_i]]^{(M, g[\textit{k}/x])}_{\text{Sense}} \rangle \in X \}$. This will be the set of kinds ep_i together with *x* help to define. For instance, $\langle x, \textit{dog}(x) \rangle$ will help

define the kinds “dog”, “white dog”, “big dog”, “big white dog”, etc. Then get the intersection of all these sets. The resulting set contains all the kinds that the whole EP conjunction helps to define. From among that set, return the most general kind – that is, the kind that has the fewest definitional hypotheses.

Now let us see how this system determines the truth values for the two scope-resolved MRSS for sentence (51) with respect to the model in Figure 4.

- (51) Every dog probably sleeps.
 (52) $\langle h0, \{h0:\text{every}(x, h1, h2), h1:\text{dog}(x), h2:\text{probably}(h3), h3:\text{sleep}(x)\} \rangle$
 (53) $\langle h2, \{h0:\text{every}(x, h1, h3), h1:\text{dog}(x), h2:\text{probably}(h0), h3:\text{sleep}(x)\} \rangle$

In (52), the top handle is $h0$. *every* has wide scope over *probably*. It means that for every dog, that dog probably sleeps, which is true in the model. In (53), the top handle is $h2$. *probably* has wide scope over *every*. It means that it is probable that every dog sleeps, which is false in the model. We will step through how the semantics for MRS described above assigns the right denotations.

$$[[(52)]]^{(M, g)} = 1 \text{ iff } \forall u \in A \text{ } [[h1]]^{(M, g[u/x])}_{Ref} \rightarrow [[h2]]^{(M, g[u/x])}_{Ref}$$

for $u = \text{FIDO}$:

$$\begin{aligned} [[h2]]^{(M, g[\text{FIDO}/x])}_{Ref} &= \\ [[\text{probably}(h3)]]^{(M, g[\text{FIDO}/x])}_{Ref} &= \\ 1 \text{ iff } [h_1 | \langle h_1, [[\text{sleep}(x)]]^{(M, g[\text{FIDO}/x])}_{Sense} \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, [[x]]^{(M, g[\text{FIDO}/x])} \rangle \in [[\text{sleep}]]^M \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, \text{FIDO} \rangle \in [[\text{sleep}]]^M \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, H_3 \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } H_8 \in R = \\ 1 \end{aligned}$$

for $u = \text{SPOT}$:

$$\begin{aligned} [[h2]]^{(M, g[\text{SPOT}/x])}_{Ref} &= \\ [[\text{probably}(h3)]]^{(M, g[\text{SPOT}/x])}_{Ref} &= \\ 1 \text{ iff } [h_1 | \langle h_1, [[\text{sleep}(x)]]^{(M, g[\text{SPOT}/x])}_{Sense} \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, [[x]]^{(M, g[\text{SPOT}/x])} \rangle \in [[\text{sleep}]]^M \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, \text{SPOT} \rangle \in [[\text{sleep}]]^M \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } [h_1 | \langle h_1, H_4 \rangle \in [[\text{probably}]]^M \in R = \\ 1 \text{ iff } H_9 \in R = \\ 1 \end{aligned}$$

$$\text{so } [[(52)]]^{(M, g)} = 1$$

$$\begin{aligned}
[[(53)]]^{(M, g)} &= \\
[[h2]]^{(M, g)}_{Ref} &= \\
[[probably(h0)]]^{(M, g)}_{Ref} &= \\
1 \text{ iff } [h_1 | \langle h_1, [[every(x, h1, h3)]]^{(M, g)}_{Sense} \rangle \in [[probably]]^M] \in R &= \\
1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, kind(h1, x), kind(h3, x) \rangle \in [[every]]^M] \rangle \in [[probably]]^M] \in R &= \\
1 \text{ iff } [h_1 | \langle h_1, [h_2 | \langle h_2, \kappa_0, \kappa_1 \rangle \in [[every]]^M] \rangle \in [[probably]]^M] \in R &= \\
1 \text{ iff } [h_1 | \langle h_1, H_6 \rangle \in [[probably]]^M] \in R &= \\
1 \text{ iff } H_{10} \in R &= \\
0 &
\end{aligned}$$

4.6 Summary

I have presented an explicit semantic account of MRS structures – a first order language where words like *every* are mapped to predicates, so there are no conventional quantifiers.

Models contain not just events, individuals and an interpretation function. They also include hypotheses and kinds. Every possible fact is given a hypothesis handle in the model. The model includes a set R , picking out which of those hypotheses are actually true. EPs (and EP conjunctions) have two-part denotations consisting of a sense and a reference. The sense is a hypothesis. Together with the set X , this constitutes a means for picking out its reference, which is a truth value.

The relationship between sense and reference is different for EPs with quantifier-predicates and other logical predicates (like *not*). They get the same kinds of senses as other types of EPs do, although those with quantifier-predicates use a special method of determining them, using kinds. However, their reference is not derived from their sense. It is calculated from the denotations of their components, much as in standard approaches.

This framework is unconventional in a number of ways that warrant further comment. It is beyond the scope of this thesis to follow these up, but I will mention them briefly here, and leave them as future work.

Frege showed that meaning must come in two parts: sense and reference. He never specified exactly what the nature of a sense should be. Standardly, senses (of sentences) are conceived of as propositions, which are sets of possible worlds – functions from worlds to truth values. I have chosen an alternative, where senses appear directly in the first-order model as hypotheses. Hypotheses can be viewed as partial descriptions of possible worlds, and thus can be mapped to sets of possible worlds. But one advantage to my approach is that different partial descriptions may lead to the same set of possible worlds. Take these two sentences:

(54) 221 is a prime number.

(55) Up is down.

These sentences are necessarily false. That is, they both represent the same proposition – the empty set of possible worlds. But they would be given different hypotheses in the

approach outlined above, and therefore different senses. Whereas the standard approach has to say something extra in order to allow (56) and (57) to have different meanings, the present approach has to say nothing more.

- (56) Kim thinks 221 is a prime number.
- (57) Kim thinks up is down.

This approach can handle notions like *probably* without the use of additional tools such as modal logic. In this framework, the semantic properties of such things could instead be studied in the same way the semantic properties of other predicates are studied.

5. TENSE

5.1 *Definition*

Comrie (1985) defines tense as the grammaticalization of location in time. This thesis is concerned with how best to represent the distinctions in meaning apparent in sentences such as (58).

- (58) a. Kim liked beans.
 b. Kim likes beans.
 c. Kim will like beans.

These sentences contain grammatical devices that serve to locate them in time. Sentences (a) and (b) use verbal morphology to locate the bean-liking in the past and in the present, respectively. Sentence (c) uses a modal verb to locate the bean-liking in the future. The languages of the world make a variety of distinctions, as outlined below, using a variety of different grammatical devices.

To be sure, there are other ways of locating events in time. For instance, in English we can use temporal adverbials as in (59).

- (59) Kim ate beans at 10:00 pm.

Here, *at 10:00 pm* locates the bean-eating in time, but does so using specific lexical items whose temporal reference is built up compositionally. Under the definition of tense given above, it does not qualify as tense. My analysis of tense needs to be able to interact successfully with other ways of locating events in time, but my primary concern will be to account for those distinctions made in the world's languages using tense.

Copestake et al (in press) propose an almost minimally bare representation of tense: a single property setting on the verb's event variable. To see if this is the best approach, let's begin by looking at more elaborate representations and see how much we can pare away.

5.2 *Existentially Quantified vs. Free Time Variables*

If tense serves to locate an event in time, let us assume that we have MRS terms that refer to the times in which the events are located. Later, we can see whether those terms are derivable from the rest of the semantic representation and may be left implicit in the MRS. For now, let us consider two basic approaches to the representation of tense: the use of existentially quantified time variables, and the use of unbound time variables.

Let us compare how these two approaches represent the meaning of the sentence in (60).

- (60) Fido barked.

An approach using existentially quantified time variables (see, for example, Dowty 1979) includes a quantifier that binds a time variable; a restriction that places that time

somewhere on the time line, and a body that relates the time to the event in question. In the current framework, this gives a representation like (61) for (60).

$$(61) \quad \langle h0, \{h1:\text{some}(t, h2, h3), h4:\text{past}(t), h5:\text{etime}(e, t) \wedge \text{bark}(e, \text{FIDO})\}, \\ \{h0 =_q h5, h2 =_q h4\} \rangle$$

The *etime* predicate is intended to represent the relation between events and their times. Here, the time of the barking event occurs within the time t . This is bound by the quantifier $h1$ and restricted by the *past* EP $h4$. The expression means that there is some time in the past, such that a Fido-barking event happened at that time.

Partee (1973) introduces an approach where tenses are treated as free variables, similarly to the way pronouns are. Here I present a related approach whereby the tense itself doesn't act like a pronoun – rather it specifies a feature of an unbound time variable, which does act like a pronoun. Here is how it works out for (60) in MRS.

$$(62) \quad \langle h0, \{h1:\text{etime}(e, t_R[\text{TENSE past}]) \wedge \text{bark}(e, \text{FIDO})\}, \{h0 =_q h1\} \rangle$$

MRS (62) says that a Fido-barking event happened at time t_R . There is no EP which predicates of t_R that it occurs in the past. Rather, there is a TENSE feature on t_R whose value is *past*, marking it as a past tense time variable. Thus, the time variable is analogous to the sort of free variable introduced by a pronoun. Just as person, number and gender features restrict the range of referents a pronoun may have, the verb's tense introduces a feature that restricts the range of referents the time variable may have.

The semantics of an MRS like (62) involves getting the denotation of t_R . According to the rules I laid out in section 4, this is determined by the variable assignment function g . Since t_R is not a bound variable, its denotation varies depending on the g used to evaluate the MRS structure for the whole sentence. My proposal is that for (at least these) free variables, the function g must always return a unique value, determined by what is salient in the speech context. The TENSE feature then acts like a presupposition: the presupposition that the salient time in the speech context will match the specification on the TENSE feature. Another way of viewing this is that the TENSE feature helps the hearer choose from among possibly several ways of construing the speech context. A [TENSE past] specification will cause her to construe the context as one in which the most salient time for the event in question is in the past.

I prefer the free-variable approach to the quantified-variable approach. My argument comes from Partee's example, reproduced here as (63), where the sentence is uttered by somebody who is just leaving on vacation. The approach using existentially quantified time variables gives (64) as the representation. The representation in (65) uses an unbound time variable marked with a TENSE feature.

- (63) I didn't turn off the stove!
- (64) $\langle h0, \{h1:some(t, h2, h3), h4:past(t), h5:not(h6), h7:etime(e, t) \wedge turn_off_stove(e, SPEAKER)\}, \{h0 =_q h5, h2 =_q h4, h6 =_q h7\} \rangle$
- (65) $\langle h0, \{h1:not(h2), h3:etime(e, t_R[TENSE\ past]) \wedge turn_off_stove(e, SPEAKER)\}, \{h0 =_q h1, h2 =_q h3\} \rangle$

MRS (64) has two scope-resolved variants. The first one, where the time quantifier has wide scope over negation, says there is some past time that does not contain an event of my turning off the stove. This statement is trivially true. The other, where negation takes scope over the time quantifier, says it is not the case that there is any past time that contains an event of my turning off the stove. This is too strong a statement. Neither of these variants reflects the meaning of (63).

MRS (65) is a much more accurate representation. It says that it is not the case that there's an event of my turning off the stove at the salient (past) reference time.

This is not to say that there is no existential quantification of times happening in the free-variable approach. Ogiwara (1996) makes the point that there is. In (65), we understand that the reference time is the period of time from when the stove was last used to when the speaker left for vacation. MRS (65) does not mean simply that there was no event of my turning of the stove that lasts precisely from the beginning of the reference time to the end of it. Rather, it means that it is not the case that *there is some time* within the reference time when the speaker turned off the stove. To represent that existential quantification explicitly, we would expect an MRS like (66), which contains both a reference time and an existential quantification.

- (66) $\langle h0, \{h1:not(h2), h3:some(t, h4, h5), h6:within(t, t_R[TENSE\ past]), h7:cotemp(e, t) \wedge turn_off_stove(e, SPEAKER)\}, \{h0 =_q h1, h2 =_q h7, h4 =_q h6\} \rangle$

The relation *cotemp* is intended to mean that the span of the event is exactly cotemporaneous with the time.

But of course this quantification need not be explicit in the MRS representation. This is what the *etime* predicate means – that the event *e* occurs *at some point* within the time t_R .⁷ Thus, the existential quantification can remain implicit in the MRS.

5.3 *Explicit vs. Implicit Reference Times*

We've seen that time variables do not need to be explicitly quantified. Are we then justified in taking the next step, and assuming, as do Copestake et al, that reference times need not be mentioned explicitly at all? Let's see how this works out for the example sentence (60), repeated here as (67). Its MRS under the free-time-variable

⁷ At least, that's what it means in this case. We will see below that the interpretation of *etime* may be different from case to case, but that interpretation is always predictable from the type of event that shows up as its first argument.

approach is repeated here as (68). The MRS where even the reference time itself is implicit is shown in (69).

- (67) Fido barked.
 (68) $\langle h0, \{h1:etime(e, t_R[TENSE\ past]) \wedge bark(e, FIDO)\}, \{h0 =_q h1\} \rangle$
 (69) $\langle h0, \{h1:bark(e[TENSE\ past])\}, \{h0 =_q h1\} \rangle$

As Copestake et al point out, (68) contains no information that cannot be reconstructed from (69). They explain what sort of evidence would be needed to motivate explicit representation of reference times: namely, that the reference time would have to show up somewhere else in the semantics. They mention temporal adverbials as one case that may appear to meet this criterion. So an example like (70) apparently requires a representation like (71).

- (70) John cried on Sunday.
 (71) $\langle h0, \{h1:etime(e, t_R[TENSE\ past]) \wedge cry(e, JOHN), h2:on(t_R, SUNDAY)\}, \{h0 =_q h1\} \rangle$

But they note that this does not actually require the explicit representation of time variables. Since there is a function from events to their times, it is always possible to let the *on* relation relate events to times rather than times to times. So sentence (70) can have the simpler MRS shown in (72).

- (72) $\langle h0, \{h1:cry(e[TENSE\ past], JOHN) \wedge on(e, SUNDAY)\}, \{h0 =_q h1\} \rangle$

However, I believe there is a class of sentence where the reference time associated with the verb's event variable must appear elsewhere in the semantics. An example is (73). The simplified approach would give the MRS in (74), and the MRS with explicit reference times is shown in (75).

- (73) John cried every Sunday.
 (74) $\langle h0, \{h1:every(x, h2, h3), h4:Sunday(x), h5:cry(e[TENSE\ past], JOHN) \wedge on(e, x)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$
 (75) $\langle h0, \{h1:every(x, h2, h3), h4:Sunday(x) \wedge within(x, t_R), h5:etime(e, t_R[TENSE\ past]) \wedge on(e, x) \wedge cry(e, JOHN)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$

MRS (74) says that on every Sunday (past, present or future), there is a (past) event of John crying. This is not the meaning of (73). Rather, what's required is what we find in (75): On every Sunday within the salient (past) reference time, there's an event of John's crying. The reference time must not only be associated (explicitly or implicitly) with the event – it must be included in the restriction of the quantifier for *Sunday*.

A possible attempt to save the simpler representation might be to mark the variable for *Sunday* as being in the past without using the verb's reference time, yielding something like (76).

$$(76) \quad \langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{Sunday}(x) \wedge \text{past}(x), \\ h5:\text{cry}(e[\text{TENSE past}], \text{JOHN}) \wedge \text{on}(e, x)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$$

Not only would this be difficult to arrive at compositionally, it is not adequate. If (73) is uttered in a context where the time in question is some particular era in John's life, it would be inaccurate to restrict the Sundays to all past Sundays. The time that restricts *Sunday* must be the *same* time as the one that restricts *cry*.

Therefore, in sentences like these, there must be an explicit reference time associated with the verb's event variable. By extension, I conclude that explicit reference times appear in all MRS representations. Only a few additions to the theory are necessary to implement this view of time variables. Figure 5 is a simplified version of the type hierarchy for variables found in the LinGO Grammar Matrix.

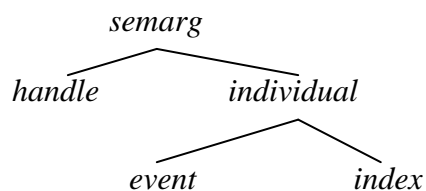


Figure 5: Variable type hierachy in the LinGO Grammar Matrix

In this hierarchy, handles are distinguished from event variables and 'normal' variables. Time variables would fit under the type *individual*. Figure 6 shows the resulting hierarchy.

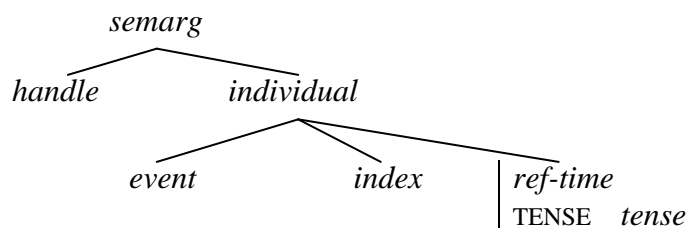


Figure 6: Variable hierarchy including time variables

The feature TENSE is specified as being appropriate for the type *ref-time*, and its value must be of the type *tense*. The subtypes of *tense* will be elaborated below, but they will include things like *past* and *present*.

5.4 Reference Times and Non-verbs

Words like *Sunday* are time sensitive. But so are many nouns that are not used as adverbial modifiers. Take for example the noun *sophomore* in sentence (77).

(77) Every sophomore took the test.

As Enç (1986) points out, the relevant time for words like *sophomore* in sentences like (77) is not completely determined by the tense of the verb. This sentence is vague with respect to whether it refers to people who are sophomores presently, those who were sophomores at the time the test was taken, or those who were sophomores at some other salient time in the past or even in the future.

This sentence doesn't use any grammatical device to locate the sophomorenness in time. That is, the vagueness isn't strictly a matter of tense. However, a complete account of tense as location in time should interact with this sort of vagueness appropriately. The present approach does so in the following way. The relations introduced by temporally sensitive nouns include an extra time argument,⁸ filled by an unbound reference time variable. The MRS for (77) would be (78).

(78) $\langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{sophomore}(x, t_{R1}), h5:\text{etime}(e, t_{R2}[\text{TENSE past}]) \wedge \text{take_the_test}(e, x)\}, \{h0 =_q h5, h2 =_q h4\} \rangle$

The time variable t_{R2} would get a PAST specification from the tense of the verb, but the variable t_{R1} would be left unconstrained. It will be identified with whatever time is salient in the context of the utterance. At least two salient times seem to be available: the speech time (call it t_S) and the event time t_{R2} . If $t_{R1} = t_S$, we get the “present sophomores” reading, If $t_{R1} = t_{R2}$, we get the “sophomores at the time of the test” reading. Of course, other readings are available as well, depending on what other salient reference times might be available in the context.

It is an interesting question, beyond the scope of this thesis, which nouns are temporal, whether all nouns, a well-defined subset, or some relatively arbitrary subset. It is enough for our present purposes that we can handle those nouns that are time sensitive.

5.5 *Explicit or Implicit Reference to the Speech Time*

If the above arguments are on the right track, we need to include reference times explicitly in MRS representations. Is there any evidence that a term representing the time of the utterance must be represented explicitly in MRS structures? So far, we have used a TENSE feature on reference times to show their relation to the speech time. Another possibility would be to have an explicit EP that relates the reference time to the speech time. So for our recurring example, repeated here as (79), we might have the MRS in (80).

(79) Fido barked.

(80) $\langle h0, \{h1:\text{etime}(e, t_R), h2:\text{precede}(t_R, t_S), h3:\text{bark}(e, \text{FIDO})\}, \{h0 =_q h3\} \rangle$

⁸ Alternatively, they may introduce an event variable, which is in turn related to a time variable with *etime*. For our present purposes it doesn't really matter, so I will use the simpler notation.

There are a number of reasons not to do this. First, reference times are inherently unbound variables. It's not clear how we can have an EP that constrains it. Normally, every label in an MRS is either associated with the top handle, or with a scopal argument in some EP. In (80), the label *h1* is the restriction for the implicit event quantifier. But the label *h2* has no such role, and there is no other EP it can be attached to. It is an orphan.

No doubt, this awkwardness could be overcome by complicating the algorithm that interprets MRS structures in the appropriate way. But in keeping with the goal of compactness, we would choose a simple TENSE feature above a whole EP anyway. There's no information in such a *precede* relation (where the 'later' argument is the speech time) that can't be derived from a [TENSE past] specification.

But most importantly, referring explicitly to the speech time in this way will sometimes make the truth conditions implied by the MRS structures too strong, leading to wrong predictions. There are uses of the present tense that do not strictly indicate intersection with the speech time. For instance, present tense is often used to indicate events in the very recent past, as when reporting on a sports event, as in (81). The two possible MRSS are given in (82) and (83), where the first uses explicit reference to the speech time, and the second uses a TENSE feature.

(81) Casey strikes out!

(82) $\langle h0, \{h1:etime(e, t_S) \wedge strike_out(e, CASEY)\}, \{h0 =_q h1\} \rangle$

(83) $\langle h0, \{h1:etime(e, t_R[TENSE\ present]) \wedge :strike_out(e, CASEY)\}, \{h0 =_q h1\} \rangle$

In (82), the striking-out explicitly co-occurs with the speech time. In (83), Another example of the present tense being used other than to refer to the speech time is the narrative present, as in (84).

(84) A guy walks into a bar.

Here, the walking isn't cotemporaneous with the speech time. Rather, the walking happened in the past, or is even just a fictional walking. The present tense is used to make it more vivid, by bringing it conceptually to the present time. Also see the discussion of relative tense in section 5.8 below for examples where a naïve use of direct references to the speech time are inappropriate.

It may be claimed that there are (at least) three different tenses, which all have the same grammatical realization in English – a 'regular' present tense, a 'hot news' tense and a 'vivid-narrative' tense. Thus, this says nothing about whether to refer explicitly to the speech time. We either have three different values for the TENSE feature, or relate the reference time to the speech time in three different ways. But there is no evidence that these are really three different tenses. If we find that one of the strategies in the world's languages is to report hot news using its own grammatical form rather than the form of the regular present tense; or that one of the strategies in the world's languages is to have a distinct vivid-narrative tense, not using the normal present tense for this purpose, then we may conclude that these are really separate tenses. Comrie

(1985), whose purpose is to explicate the cross-linguistic facts about tense, mentions no such languages in his discussion of the present tense, although he mentions the ‘hot news’ use of the present. Thus, I prefer to posit a single present tense.

But if we have a single present tense, then characterizing it explicitly in the semantics as overlapping with the speech time makes the wrong predictions. With the TENSE feature approach, it is up to the variable assignment function (which I am assuming is another way of saying the pragmatic speech context) to assign an appropriate time referent to time variables specified as [TENSE present]. To be sure, this is just pushing the problem of how to characterize the present tense from the semantics to the pragmatics, and I don’t provide a complete answer for how the pragmatics does it. Nonetheless, the choice of a time reference for present tense does seem to be crucially dependent on pragmatics. I leave it as an open question.

Let us now turn to the tense distinctions made in natural languages. I’ll begin by continuing my remarks about the present tense.

5.6 *Present tense as a punctual tense*

The present tense is canonically used to locate an event at the present (i.e. the speech time), although, as we have seen above, there are other, more or less related, uses to which the present tense may be put. In its typical use, it is a ‘punctual’ tense. That is, since the speech time is conceived of as a single moment in time, the present tense is restricted in how it can be interpreted for various kinds of events. In particular, unlike the reference times we have seen marked as [TENSE past] or [TENSE future], present reference times, in their normal use, cannot wholly contain within them events that extend through time. The way the present tense is interpreted is thus different from the way the past tense, say, is interpreted, and furthermore varies with the type of event it is associated with. Let’s take sentences (85) - (87) for example.

- (85) Harriet ate raisins
- (86) Harriet eats raisins
- (87) Harriet likes raisins

Sentence (85) uses a past reference time, which may endure for a period of time. Thus, the whole raisin-eating situation can occur within it. On the other hand, sentence (86) uses a present reference time, which cannot contain a raisin-eating situation within it. And sure enough, (86) doesn’t refer to a particular raisin-eating situation. Rather, it refers to Harriet’s habit of eating raisins. On the other hand, (87) can refer to a particular raisin-liking situation. But rather than being contained within the reference time, the relation is reversed: the temporal extent of the raisin-liking situation contains the reference time.

Thus, there appear to be (at least) two different kinds of situations. Those like the ones associated with the verb *eat*, which need to be contained within their reference times, and those like the ones associated with the verb *like*, which surround their reference times. Vendler (1957) calls the first class of verbs *activities*, and the second class of verbs *states*. I propose to distinguish activity events from stative events, and

thus account for their differing behavior in the present tense, by elaborating the type hierarchy for event variables.

I propose to create subtypes in the hierarchy of variables that distinguish events that surround their reference times from those that are contained within them. I'll call these types *imperf-event* and *perf-event*, respectively. This will be elaborated further, and the significance of the names of these types will be made clearer, in section 6.1, where I deal with aspect.

Figure 7 contains the new hierarchy.

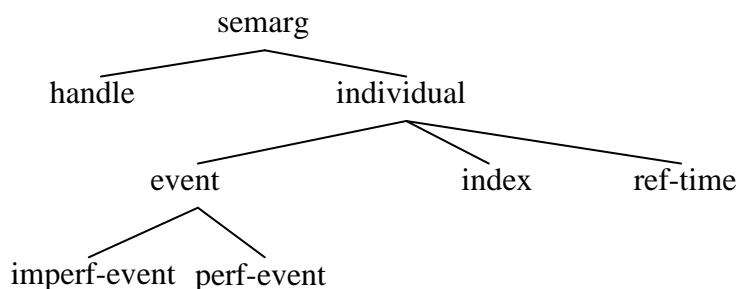


Figure 7: Revised variable type hierarchy

In addition, I propose to elaborate the type hierarchy of relations. I propose two subtypes of the type *relation*. One, *imperf-relation* will be specified to take *imperf-event* variables, and the other, *perf-relation*, will be specified to take *perf-event* variables. The relation whose predicate is *eat* will inherit from *perf-relation*, and the relation whose predicate is *like* will inherit from *imperf-relation*.

Given this system, let us now look at the MRSS for (85) - (87), given here as (88) - (90), respectively.

- (88) $\langle h0, \{h1:etime(e_1, t_R[\text{TENSE past}]) \wedge eat(e_1, \text{HARRIET}, \text{RAISINS})\}, \{h0 =_q h1\} \rangle$
 (89) $\langle h0, \{h1:etime(e_2, t_R[\text{TENSE present}]) \wedge eat(e_2, \text{HARRIET}, \text{RAISINS})\}, \{h0 =_q h1\} \rangle$
 (90) $\langle h0, \{h1:etime(e_3, t_R[\text{TENSE present}]) \wedge like(e_3, \text{HARRIET}, \text{RAISINS})\}, \{h0 =_q h1\} \rangle$

These MRSSs are completely parallel, which is what we want, given that the sentences are grammatically parallel. The only differences are the tenses and the types of the event variables e_1 , e_2 and e_3 . The first two are *perf-events*, and the third is an *imperf-event*. This is the key that tells the component that interprets the MRSSs whether to interpret the *etime* relation as saying that the reference time includes the event time or the other way around. In (88), the *perf-event* signals that the event time should be interpreted as within the reference time, and we get a raisin-eating event contained within a past time. In (90), the *imperf-event* signals that the event time should be interpreted as surrounding the reference time, and we get a raisin-liking event that continues from before the reference time begins until after it ends. In (89), however, the event time should also be interpreted as within the reference time. This just isn't

possible for the normal interpretation of a present reference time as denoting the speech time. One way around this is to understand this as a ‘hot-news’, ‘vivid-narrative’ use of the present tense. Although these uses rely on an analogy to the speech-time present tense, their actual reference times they use are not punctual. Another possibility is that there is an additional MRS for sentence (86) that uses an *imperf-event*. I will argue below that this is just how we get the reading where Harriet is in the habit of eating raisins.

5.7 Basic tense distinctions

According to Comrie (1985), there are many basic ways that the languages of the world divide up the time line. Distinct tenses for past, present and future are quite common. Neither is it unusual for there to be a basic split between past and non-past. This is the case, for example in German, as illustrated by (91), where the so-called present tense is the verb form used to indicate future time as well.

- (91) ich gehe morgen.
 I go-non-past tomorrow
 ‘I will go tomorrow.’

Comrie also notes that, although much rarer, there are languages that have a basic distinction between future and non-future. He notes Hua, a New Guinea language, as an example, but gives no sample sentences.

Comrie also notes that there appear to be no languages where there is a basic distinction between present and non-present. Given this state of affairs, I propose the following (provisional) type hierarchy for values of the TENSE feature.

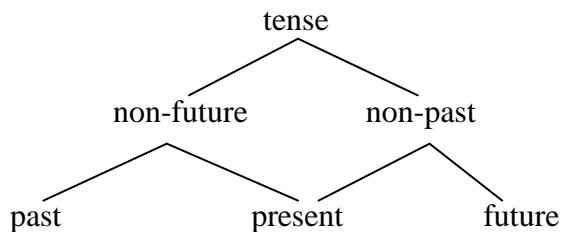


Figure 8: Preliminary type hierarchy for values of TENSE

So the TENSE feature, appropriate for *time-ind* objects must take a value whose type is *tense*. Immediate subtypes of *tense* are *non-future* and *non-past*. *Past* is a subtype of *non-future*, and *future* is a subtype of *non-past*. *Present* inherits both from *non-future* and from *non-past*. I hypothesize that this hierarchy (plus the additions to it described below) forms the stock of tenses available to the languages of the world. Any particular language will contain a subset of these tenses, and none will contain any other tenses.

Comrie notes that there are tenseless languages, mentioning Burmese as an example. That is, although there may be ways of locating an event in time using lexical means, there is no grammatical device that does so. This would be parallel to the situation for English nouns like *sophomore*, as I have described it, where the event variable is associated with a reference time, but that reference time’s TENSE feature is

completely unspecified. So the MRS in these sentences would still specify that the event takes place at a contextually salient reference time, but there is no restriction on which salient reference time should be used.

Comrie notes that many languages have tenses that draw finer distinctions than past, present and future. It is normally the past tenses that show these distinctions, but there are languages with such distinctions in the future tense as well.

Common cut-off points include the following:

- immediate past
- recent past (from yesterday to a week or a few months ago) vs. non-recent past (earlier than that)
- remote past (more than a few days ago) vs. non-remote past (not more than a few days ago)
- hodiernal past (today) vs. pre-hodiernal past (before today)
- hesternal (before today, but not more than a few days ago)
- close future vs. remote future
- hodiernal future (today) vs. post-hodiernal future (after today)

These distinctions translate into a type hierarchy such as Figure 9 for tenses:

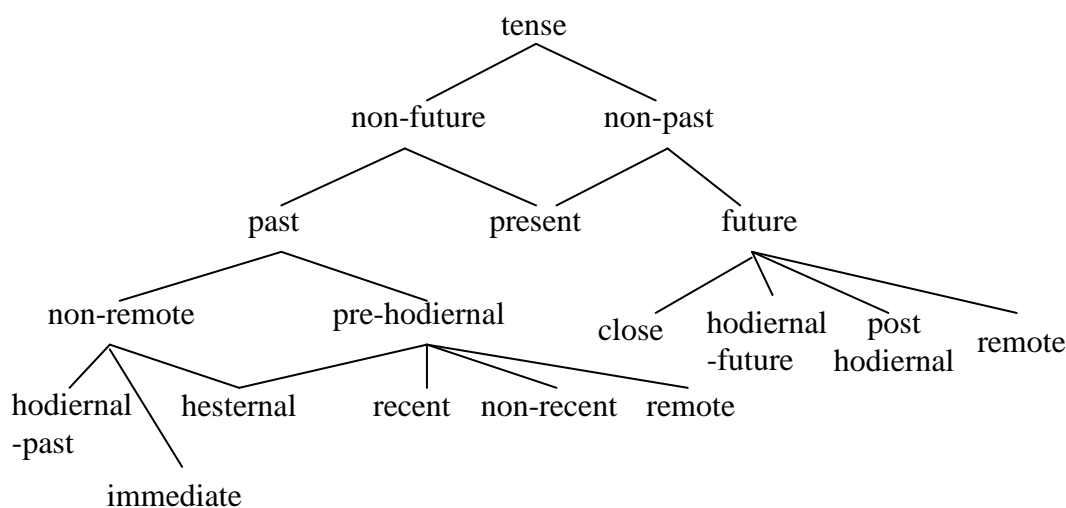


Figure 9: Final type hierarchy for tense.

5.8 *Relative tense*

Comrie calls the tenses mentioned above *absolute tenses*, which he contrasts with the notion of *relative tense*. The idea is that where absolute tense locates an event in time relative to the speech time, relative tense locates an event in time relative to some other event (or time). He illustrates with two sorts of examples. The first sort is typified by sentence (92).

(92) The passengers awaiting flight 26 proceeded to departure gate 5.

In one reading, the time of awaiting flight 26 is not absolute (i.e. relative to the speech time). Rather, it is understood as relative to (i.e. equal to) the time of proceeding to gate 5. Depending on the context, other readings may have the time of awaiting flight 26 as being relative to other salient reference times, including the speech time.

Sentences such as this can be accounted for in much the same way as with the *sophomore* example (77). The idea is that non-finite forms such as the participial *awaiting flight 26* have no morphosyntactic tense, and hence don't specify the TENSE feature of the reference time. Thus, the reference time may match any salient time. The MRS for (92) is given in (93).

- (93) $\langle h0, \{h1:\text{the}(x, h2, h3), h4:\text{etime}(e_1, t_{R1}), h5:\text{passenger}(x) \wedge$
 $\text{await}(e_1, x, \text{FLIGHT26}), h6:\text{etime}(e_2, t_{R2}[\text{TENSE past}]) \wedge$
 $\text{proceed}(e_2, x, \text{GATE5})\}, \{h0 =_q h6, h2 =_q h5\}\rangle$

The reference time t_{R2} , which is associated with the proceeding event, is specified as being a past tense time. The reference time t_{R1} is unspecified. Two plausible salient times that it may refer to are t_{R2} and the speech time, but others are possible as well.

In the other sort of example that Comrie gives, there is a morphosyntactic specification for tense, but that tense is not interpreted with respect to the speech time; rather it is interpreted with respect to the tense of a clause it is embedded in. This is illustrated by (94) - (96), from Imbabura Quechua.

- (94) Marya Agatupi kawsajta krirkani.
 Mary Agato-LOC⁹ live-PRES I-believe-PAST
 'I believed that Mary lived in Agato.'
- (95) Marya Agatupi kawsashkata krirkani.
 Mary Agato-LOC live-PAST I-believe-PAST
 'I believed that Mary had lived in Agato.'
- (96) Marya Agatupi kawsanata krikani.
 Mary Agato-LOC live-FUTURE I-believe-PAST
 'I believed that Mary would live in Agato.'

In these examples, the tense on the embedded verb is being interpreted relative to the reference time associated with the matrix verb. So in (94), the present tense on *kawsa* locates the living at the same time as the believing, not the same time as the speech time. Similarly for the past tense in (95) and the future tense in (96).

⁹ Comrie doesn't give a word-by-word gloss (though he does mark the tenses of the verbs). I am speculating about some of the morphology

I assume that in these cases, the MRS faithfully reflects the morphological tense of the verb. So for instance, (94) would get an MRS like the one in (97).

$$(97) \quad \langle h0, \{h1:etime(e_1, t_{R1}[\text{TENSE past}]) \wedge believe(e_1, I, h2), \\ h3:etime(e_2, t_{R2}[\text{TENSE present}]) \wedge live(e_2, MARY, AGATO)\}, \{h0 =_q h1, \\ h2 =_q h3\} \rangle$$

If this is the right decision, it is another reason why not explicitly referring to the speech time is also a good decision. Here, we don't say that [TENSE present] necessarily means cotemporaneous with the speech time. That is left up to the interpretive component. My assumption here is that tenses associated with embedded events are interpreted relative to the tenses associated with the events they are embedded in.

What about languages like English, where the tense of the embedded clause appears to locate that clause relative to the speech time rather than relative to the time of the matrix event? That is, in (98), the English equivalent of (94), the embedded verb is in the past tense, but the time of the living is interpreted as the same as the time of the believing.

$$(98) \quad \text{I believed that Mary lived in Agato.}$$

If we make the assumption that the interpretive component is language-independent, the MRSs for these sentences from the two languages must be the same. Following analyses like Ogihara (1996), I take languages like Imbabura Quechua to have the more transparent syntax-semantics interface. It is in sequence-of-tense languages like English where something additional has to be said.

First, note that (98) is ambiguous. It can mean either that I believed Mary lived in Agato at the time of my believing, or that I believed Mary lived there prior to the time of my believing. So giving it the same straightforward MRS as we would for (95), where the time of the living is prior to the time of the believing is still appropriate. What we have to do is account for how it can also get an MRS like (97) (or something equivalent), where the time of the living is coincident with the time of the believing.

We have two choices. First, we can follow Ogihara's approach, in which an embedded tense is optionally deleted when it is the same as the higher tense. In our present terms this means treating a morphological past tense as if it were present when it appears in an embedded context. Thus, (98) would get an MRS just like (97). This could be tricky to implement given assumptions in the MRS literature about compositionality. Present tense morphemes would have to be ambiguous between [TENSE past] and [TENSE present], allowing the latter only to unify with embedded contexts.

The other possibility is to directly equate the reference times of the two events, giving an MRS like (99).

$$(99) \quad \langle h0, \{h1:etime(e_1, t_{R1}[\text{TENSE past}]) \wedge believe(e_1, I, h2), h3:etime(e_2, t_{R1}) \wedge \\ live(e_2, MARY, AGATO)\}, \{h0 =_q h1, h2 =_q h3\} \rangle$$

This approach could be implemented in the interpretive component. Or it could be implemented in the syntax-semantics interface by exposing the time variable in the way that's consistent with MRS assumptions about compositionality. It is beyond the scope of this thesis to argue for one of these approaches over the other. The point for our present purposes is that it might be done one way or the other.

Comrie also introduces the notion of *absolute-relative* tense. By this he means a single form that indicates an event is located relative to a time which is itself located relative to the speech time. This describes, for example, the English pluperfect, which (arguably) locates an event prior to some time which is in turn located prior to the speech time. Take for instance sentence (100).

(100) Millie had eaten the cookie.

This is generally taken to mean that there is some time before the speech time, and that Millie ate the cookie before that time. We have several choices for how we might represent this. First, we can consider the possibility of adding more possible values for the TENSE feature. Under this approach, (100) could simply get an MRS like (101).

(101) $\langle h0, \{h1:etime(e, t_R[TENSE\ pluperfect]) \wedge eat(e, MILLIE, THE\ COOKIE)\}, \{h0 =_q h1\} \rangle$

Another possibility is that we could keep our original TENSE values, but specify that the eating event happens prior to the reference time rather than at the reference time. This approach yields an MRS like (102).

(102) $\langle h0, \{h1:precede(e, t_R[TENSE\ past]) \wedge eat(e, MILLIE, THE\ COOKIE)\}, \{h0 =_q h1\} \rangle$

The problem with either of these approaches is that it leaves us with no representation of any event before which the cookie-eating event takes place. So if, for example, we have a temporal adverbial which restricts this event, as in (103), there is no variable in the MRS that it can restrict.

(103) Millie had (already) eaten the cookie on Sunday.

In one reading of this sentence, there was some time before Sunday when Millie ate the cookie. The *on Sunday* EP should relate Sunday to some event, but no such event appears in (101) or (102).

The solution must be to explicitly represent the additional event. If we do, we have two possibilities. We can either introduce a reference time for each event and order the reference times with respect to one another, or we can simply order the events themselves with respect to one another. For sentence (103), this leaves us with MRSS (104) and (105), respectively.

- (104) $\langle h0, \{h1:etime(e_1, t_{R1}[TENSE\ past]) \wedge on(e_1, SUNDAY), h2:etime(e_2, t_{R2}) \wedge eat(e_2, MILLIE, THE\ COOKIE), h3:precede(t_{R2}, t_{R1})\}, \{h0 =_q h2\} \rangle$
- (105) $\langle h0, \{h1:etime(e_1, t_{R1}[TENSE\ past]) \wedge on(e_1, SUNDAY), h2:precede(e_2, e_1) \wedge eat(e_2, MILLIE, THE\ COOKIE)\}, \{h0 =_q h2\} \rangle$

I will assume the second of these two options. In (104), the *precede* EP relates two free variables. We get the same awkwardness as we did in section 5.5, where we considered referring to the speech time with an explicit variable. Normally, every label in an MRS is either associated with the top handle, or with a scopal argument in some EP. This is not the case for the label *h3*. In addition, in (105) we can do without the second reference time altogether. To the degree that more compact representations are better, this argues in favor of (105).

It may be argued that the English pluperfect is really just the past tense of the perfect aspect (which will be addressed in the section on aspect), and not really an absolute-relative tense. Comrie argues that this is not the case, but I will not review this argument here. Whether or not this is true for English, it is not the case for every language. Comrie mentions that literary Portuguese has a simple pluperfect. There are languages (such as Maltese) that have a pluperfect but no distinct perfect.

Many tense combinations are possible. Comrie mentions the pluperfect (before the past) and the future perfect (before the future) in English. He notes that Latin can form an absolute-relative construction which indicates the event happens after a future reference time.

- (106) datūrus erit.
 about-to-give he-will-be
 ‘he will be about to give.’

He also gives an example from English of an absolute-relative construction where the event happens after a past reference time.

- (107) John left for the front; he would never return.

5.9 Summary

To account for tense, I have proposed the use of a free time variable, associated to an event variable with an EP whose predicate is *etime*. Time variables find their place in the type hierarchy as a subtype of *individual*, either sister to *index* or as a subtype of it.

The time variable is given its interpretation through the assignment function *g*. The value that *g* must return for the time variable is the one which is the salient time in the utterance context. The time variable has a TENSE feature, which also constrains which time the function *g* can return, locating it on the time line relative to the speech time (or the time of an event it is embedded in). Thus, the TENSE feature acts as a presupposition that the salient time in the context will match its specification. Reference

times are used not just for the representation of tensed verb meanings, but for at least some noun meanings and non-finite verb forms as well.

I have proposed that event variables be broken into distinct types: *perf-event* and *imperf-event*. The *etime* predicate is to be interpreted so that the reference time surrounds the temporal extension of a *perf-event*, but is included within the temporal extension of an *imperf-event*.

Based on the tense distinctions made in the world's languages, I propose a type hierarchy for *tense* (which is the type of the value of the TENSE feature) as shown in Figure 9. The basic distinction are between *future* and *non-future*; and between *past* and *non-past*. The *present* tense inherits from both *non-future* and *non-past*. There are a number of other tenses which are specializations of *past* and *future*, with differing degrees of remoteness.

With grammatical forms such as the pluperfect, where an event is temporally located with respect to another event, which is in turn located with respect to the utterance time, I propose explicitly representing this intermediate event, and associating it with a TENSE value as normal. The other event is related to the tensed event with a temporal ordering relation such as *precede*.

6 ASPECT

In defining aspect, Comrie (1976) says that ‘aspects are different ways of viewing the internal temporal constituency of a situation’. In this section, I will look at two broad categories of aspectual distinctions: the perfective-imperfective, and the perfect-nonperfect distinctions. More specific distinctions such as *habitual* and *inceptive* will be treated as instances of these broader distinctions.

6.1 *Perfective vs. Imperfective*

The distinction between perfective vs. imperfective aspect is well-known, and is stated well by the glossary of linguistic terms on the SIL International web site¹⁰: “Perfective aspect is an aspect that expresses a temporal view of an event or state as a simple whole, apart from the consideration of the internal structure of the time in which it occurs; Imperfective aspect is an aspect that expresses an event or state, with respect to its internal structure, instead of expressing it as a simple whole.”

In section 5.6, I argued for a distinction in the type hierarchy between types of events that are interpreted as occurring within their associated reference times, and types of events that are interpreted as surrounding their reference times. As the names of these types are intended to suggest, the first type of event is inherently perfective and the second type of event is inherently imperfective. That is, a perfective event reveals no internal structure. Its reference time cannot be within it, as there is no ‘within’ in a perfective event. An imperfective event, on the other hand, does reveal its internal structure, so its reference time can be represented as occurring within its temporal boundaries. In this section, I’ll be looking at aspect as it is stored on lexical items and subsequently affected by morphological processes. The resulting proposal will bear a distinct relation to Vendler’s (1957) action types.

I have characterized the present tense as a punctual tense. That is, it marks a reference time as being a single point in time. On the other hand, a tense such as the past tense marks a reference time as being an interval extended through time. Thus, we are left with some predictions about what sorts of events can occur with what sorts of tenses. In particular, perfective events should not be able to occur in the present tense. Let’s look at the sentences (108) - (111).

- (108) Kim liked Sandy.
- (109) Kim likes Sandy.
- (110) Kim talked to Sandy.
- (111) Kim talks to Sandy.

The verb *like* (and other stative verbs) are marked lexically as being associated with imperfective event variables. The verb *talk (to)* (and other activity verbs) are marked

¹⁰ <http://www.sil.org/linguistics/GlossaryOfLinguisticTerms/WhatIsPerfectiveAspect.htm> and <http://www.sil.org/linguistics/GlossaryOfLinguisticTerms/WhatIsImperfectiveAspect.htm>, December 2005.

lexically as being associated with perfective event variables. We can see that all the examples (108) - (111) are grammatical. The combination of the perfective verb *talk* and the present tense, which is predicted to be impossible, actually shows up as the grammatical (111). What's going on? First, notice that (leaving aside uses of the present such as 'hot news' and 'vivid narrative' uses) (111) doesn't refer to any actual talking event, but rather to Kim's habit of talking to Sandy. This is not the case for the imperfective example (109), which, for at least the most natural reading, does refer to an actual event of liking. This difference alone is enough to motivate some difference between *like* and *talk*.

Habitual

To account for the grammaticality of (111) I assume the existence of aspectual shift operators, which are common in the literature. My approach is similar to that of Bonami (2002), who also uses them within an HPSG/MRS framework. In this particular case, I assume the existence of an operator *habitual* which relates one of its arguments, which must be an imperfective event, to an *event-kind*, which it is a habitual expression of. So (111) gets the MRS in (112).

$$(112) \langle h0, \{h1:etime(e_1, t_R[TENSE \text{ present}]) \wedge habitual(e_1, e_2, h2), \\ h2:talk-to(e_2, KIM, SANDY)\}, \{h0 =_q h1\} \rangle$$

MRS (112) says that there is an event (e_1) associated with a present reference time. This event is the habitual expression of the event-kind defined by the combination of e_2 and $h2$, which is the Kim-talking-to-Sandy kind of event. Recall that the *talk-to* EP is specified lexically so that it can only take perfective event variables. But e_1 has no such restrictions. In fact, I assume the *habitual* operator can only take an imperfective event variable as its first argument. So even though the *talk-to* relation is specified as perfective, it doesn't mean that the activity of talking to somebody has no internal structure. It is just that that structure is not available from the relation supplied in the lexicon. It can become available through an aspectual expression related to it via an aspectual operator such as *habitual*.

Although this is not the place to go into the syntactic details, I assume that the habitual operator is introduced by a lexical rule. Lexical rules are a specific sort of syntactic rule that the LinGO Grammar Matrix makes available. They are unary-branching rules whose mother and daughter nodes are both lexical items. These rules are in general allowed to change the morphological form of the word, but in the case of the habitual operator, it would not. The lexical rule would provide the *habitual* EP and constrain its second argument to be identical with the hook of the input to the lexical rule. The first argument of the *habitual* EP becomes the hook of the output from the rule.

Bonami doesn't provide a model-theoretic account of what aspectual operators do. Here I present an account in terms of the sort of model I introduced in section 4. Just as an individual-kind (such as the kind "dogs") can be defined by an individual variable and a set of EPs containing that variable, an event-kind can be defined by an event

variable and a set of EPS containing that variable. Figure 10 is a model in which we can interpret MRS (112).

$$\begin{array}{l}
 E = \{E_1\} \\
 A = \{KIM, SANDY, T_1\} \\
 L = \{H_0, H_1, H_2, \dots\} \\
 K = \{K_1, \dots\} \\
 X = \{\langle K_1, H_0 \rangle, \dots\} \\
 \\
 F = \left\{ \begin{array}{l}
 talk-to \rightarrow \{\langle H_0, K_1, KIM, SANDY \rangle, \dots\} \\
 habitual \rightarrow \{\langle H_1, E_1, K_1 \rangle, \dots\} \\
 etime \rightarrow \{\langle H_2, E_1, T_1 \rangle, \dots\}
 \end{array} \right. \\
 \\
 R = \{H_1, H_2\}
 \end{array}$$

Figure 10: Model for *Kim talks to Sandy*

This model contains the individuals KIM and SANDY, and the time T_1 . (Although it could be that times should be separated from other entities in the model, this is not important for my current point.) There is also the kind K_1 , which is defined by the handle H_0 , and is the kind for events of Kim talking to Sandy. Hypothesis H_1 is the hypothesis that E_1 is the habitual expression of kind K_1 . Hypothesis H_2 is the hypothesis that T_1 is the time of event E_1 . Both hypotheses H_1 and H_2 are true.

Aspectual operators, such as *habitual* are interpreted a bit differently from conventional relations, and a bit differently from quantifier relations. Like quantifier relations, they relate kinds to other things. But like conventional relations, their reference is determined by looking up their sense in the set R . Here is the definition for interpreting aspectual operators:

- For operator EPS $P(e_1, e_2, h1)$,

$$\begin{aligned}
 \llbracket P(e_1, e_2, h1) \rrbracket^{(M, g)}_{Sense} &= h \mid \langle h, \llbracket e_1 \rrbracket^{(M, g)}, kind(h1, e_2) \rangle \in \llbracket P \rrbracket^M \\
 \llbracket P(e_1, e_2, h1) \rrbracket^{(M, g)}_{Ref} &= 1 \text{ iff } \llbracket P(e_1, e_2, h1) \rrbracket^{(M, g)}_{Sense} \in R
 \end{aligned}$$

So the sense of an operator EP is the hypothesis label that corresponds to the tuple in the operator's relation that relates the first event argument of the EP to the event-kind determined by the second event argument of the EP and the EP's handle argument.

Notice then that in (112), the event variable e_2 isn't bound by a quantifier in the normal way. In effect, it is bound by the operator. Just as when a variable is "bound" by a quantifier when determining its sense, the event variable here is used to determine a kind. As such, there need not be any actual talking event in order for the habitual event to be true. This is what we want. For instance, imagine that part of Kim's job duties was to talk to various people, and Kim is assigned a different talking partner every week. Suppose that on this particular Monday, Kim is assigned to talk to Sandy. On the

morning of that Monday, it is possible to utter (111) truthfully before Kim has talked to Sandy. And indeed, Kim's assignment may change before any talking ever actually happens.

Also, note that in example (112), the handle *h2* appears both as an argument of the *habitual* operator, and as the label of the *talk-to* relation. Most handle arguments are related to EP labels with the $=_q$ relation, so that quantifiers can have different scopal relationships with them. Here, that doesn't seem possible. Using the $=_q$ operator, the sentence (113) would have the MRS in (114), leading to the three scope-resolved readings (115) - (117).

- (113) Every person talks to Sandy.
 (114) $\langle h0, \{h1:\text{every}(x, h2, h3), h4:\text{person}(x), h5:\text{etime}(e_1, t_R[\text{TENSE present}]) \wedge \text{habitual}(e_1, e_2, h6), h7:\text{talk-to}(e_2, x, \text{SANDY})\}, \{h0 =_q h5, h2 =_q h4, h6 =_q h7\}\rangle$
 (115) $\text{every}(x, \text{person}(x), \text{exist}(e_1, \text{etime}(e_1, t_R[\text{TENSE present}]) \wedge \text{habitual}(e_1, e_2, \text{talk-to}(e_2, x, \text{SANDY}))))$
 (116) $\text{exist}(e_1, \text{etime}(e_1, t_R[\text{TENSE present}]) \wedge \text{every}(x, \text{person}(x), \text{habitual}(e_1, e_2, \text{talk-to}(e_2, x, \text{SANDY}))))$
 (117) $\text{exist}(e_1, \text{etime}(e_1, t_R[\text{TENSE present}]) \wedge \text{habitual}(e_1, e_2, \text{every}(x, \text{person}(x), \text{talk-to}(e_2, x, \text{SANDY}))))$

Reading (115) is the natural reading of (113), which says that for every person, there is a present state which is the habitual expression of an activity-kind of that person talking to Sandy. Reading (117) is pragmatically odd, but still makes sense. It says that there is a single present state which is the habitual expression of a single activity-kind where everybody is involved in cooperatively talking to Sandy. It is reading (116) that we want to rule out. It says that there is a single present state, such that, for every person, that state is the habitual expression of an activity-kind of that person talking to Sandy. I do not know what it could mean for a single state to be the habitual expression of more than one distinct activity-kind. Thus, I conclude that the *habitual* operator (and by similar reasoning, other operators to be introduced below) take EP labels directly as arguments, without using a $=_q$ constraint.

The *habitual* operator constrains its first argument to be an imperfective event variable. How about its second argument? We've seen it can take a perfective event variable. Can it take imperfective variables as well? The test is whether or not (109), repeated here as (118), can have a habitual reading.

- (118) Kim likes Sandy.

It is strangely difficult for me to say whether it does or not. It would be handy for this approach to aspect if (118) did not have a habitual reading. This is so for the following reasons. First, the habitual operator, in English, is not associated with any morphosyntactic structure. The input to the *habitual* lexical rule looks morphosyntactically just like its output. If the habitual operator can relate imperfective

events to other imperfective events, it is not clear that there is an elegant way to keep the rule from applying to its own output. That is, there may be no good way to keep a sentence like (118) from meaning that Kim is in the habit of being in the habit of being in the habit ... of liking Sandy. However this kind of problem can always be prevented by adding a diacritic feature to the output of the rule whose only purpose is to prevent it from being used as the input to the rule.

Progressive

Let us turn our attention now to sentences (120) - (123). In (123), just as in (111), repeated as (119), an underlyingly perfective verb is being used in conjunction with the present tense with no ill effects.

- (119) Kim talks to Sandy.
- (120) * Kim was liking Sandy.
- (121) * Kim is liking Sandy.
- (122) Kim was talking to Sandy.
- (123) Kim is talking to Sandy.

Once again, I propose an aspectual operator that relates perfective event variables to imperfective event variables. This time, it is the *progressive* operator. Sentence (123) gets the MRS in (124).

- (124) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge progressive(e_1, e_2, h2), h2:talk-to(e_2, KIM, SANDY)\}, \{h0 =_q h1\} \rangle$

Here, the *progressive* operator relates the activity-kind of Kim talking to Sandy ($e_2 - h_2$) to its progressive expression (e_1). MRS (124) means that the present time stands within an event which is the progressive expression of the idea of Kim talking to Sandy.

Unlike the habitual operator, the progressive in English is accompanied by morphosyntactic structure: something in the combination of the auxiliary *be* and the suffix *-ing*. Thus, we have a pretty good diagnostic about what sorts of event variables it can relate its imperfective event variable to. Sentences (120) and (121) show that the progressive operator must relate a perfective event variable with an imperfective event variable. The verb *like* is lexically specified as being imperfective. Sentences with this verb in the progressive form are just ungrammatical.

It may be objected that (120) and (121) can be ruled out on purely pragmatic grounds, and need not be ruled out on the basis of their MRS structures. That is, the meaning of the verb *like* is just not the kind of thing that can be progressivized. Some story might be told about the progressive requiring a process where there is a continual change of state, or where there is some continual input of energy. But it is hard to see how such stories can classify the verb *sit* as a perfective. Sentence (125) is fine, even though the verb is in the progressive.

- (125) The cat was sitting there all day.

In addition, Comrie points out that different languages have different rules for when the progressive can be used, or in my terms, when a verb is to be classed as a perfective or imperfective. In English, the verb *rain* acts like a perfective. That is, it cannot appear with bare present-tense morphology (except as a habitual), but it can appear with progressive morphology:

(126) * It rains.

(127) It is raining.

In Icelandic, it acts as an imperfective. It can appear with bare present-tense morphology, but it cannot appear with progressive morphology.

(128) hann rignir.
It rain-present
'It is raining.'

(129) * hann er að rigna.
It rain-progressive

In English, verbs like *see* and *hear* pattern with the imperfectives; in Portuguese the corresponding verbs pattern with the perfectives. My conclusion is that although there are some regularities, in the end the determining factor of whether a given verb is associated with a perfective or imperfective event variable is arbitrary, and must be specified in the lexicon explicitly.

It's pretty clear that perfectives must be situated within their reference times, but imperfectives may surround their reference times. But is it possible for an imperfective to be situated within its reference time as well? If imperfectives are required to surround their reference times, then a sentence like (130) must mean something like (131).

(130) Terry was running yesterday.

(131) Terry was running at some point yesterday.

The progressive *running* in (130) is imperfective; the reference time is lexically specified to be yesterday. Unless Terry was running all day yesterday (which is not an entailment of (130)), the reference time must be some point within yesterday.

Indeed, this seems to be the case. The progressive implies a reference time that can fit within the event, whereas the simple past does not:

(132) Terry was running yesterday, when suddenly there was an earthquake.

(133) ? Terry ran yesterday, when suddenly there was an earthquake.

In (132), the reference time is compatible with the time that something suddenly happened, which is certainly a smaller span than the whole of yesterday. On the other

hand, with the perfective (133), the reference time appears to be the whole day yesterday, a span too big to be cotemporaneous with an earthquake.

Also, two incompatible non-progressive activities can be reported using the same reference time, but two incompatible progressive activities cannot:

- (134) I sat and I stood.
 (135) ? I was sitting and I was standing.

In (134), the (perfective) sitting and standing could easily have happened at different points within the single reference time. In (135), a single reference time cannot be within both an event of sitting and an event of standing.

My conclusion is that across languages, the interpretive component interprets perfectives in one way with respect to their reference times, and interpretes imperfectives the other way.

Perfective-to-Imperfective Operators in General

The habitual operator and the perfective operator both relate perfective event variables to imperfective event variables. We can capture a generalization by positing a more general perfective-to-imperfective operator, of which the others are subtypes. I propose the following hierarchy.

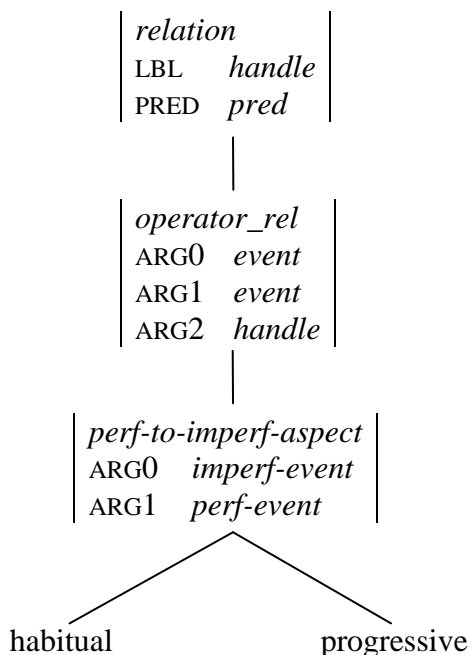


Figure 11: Hierarchy for perfective-to-imperfective operators

One benefit of arranging these operators into a hierarchy is that different languages are free to make more or less fine-grained aspectual distinctions. According to Comrie, the Spanish sentence (136) can be translated into English in two ways:

- (136) Juan canto.
 Juan sing-PRES
 ‘Juan sings.’ / ‘Juan is singing.’

This could be handled by treating (136) as ambiguous, giving it one representation with the progressive operator, and one with the habitual operator. Or we can treat it as vague, giving it a single unified (or underspecified) reading by using the parent operator common to both.

Various languages may have operators of other types as well. In Akan, there is a distinction between progressive on the one hand, and continuative on the other. Whereas the progressive operates on activities (to create states), the continuative operates on states (to make other states). Such an operator wouldn't fit under *perf-to-imperf-aspect*, but would rather appear under a different abstract operator *imperf-to-imperf*.

Punctual vs. Durative Perfectives

Perfective event variables divide into two subtypes: punctuals and duratives. Punctuals are conceived as happening at moments in time, and duratives extend over a period of time. This distinction is necessary to account for the following data.

- (137) Harriet juggles the raisins.
 (138) Harriet juggled the raisins.
 (139) Harriet is juggling the raisins.
 (140) Harriet was juggling the raisins.
 (141) ? Harriet finds the raisins.
 (142) Harriet found the raisins.
 (143) ? Harriet is finding the raisins.
 (144) ? Harriet was finding the raisins.

The sentences with *juggle* behave as other activities we have seen before. They work in the past tense. In the present tense, they take on a habitual reading. They can be progressivized. The sentences with *find* also work in the past tense. But they don't work at all in the present tense (barring ‘hot news’ or ‘vivid narrative’ readings),¹¹ and they cannot be progressivized.

My explanation is that, as I've said before, all perfectives occur within their reference times, and are thus incompatible with the present tense. The difference is that the habitual and progressive operators only apply to durative perfectives like *juggle*, not to punctual perfectives like *find*. So (137) is saved by the habitual operator, whereas (141) cannot be.

So I need to update the event variable type hierarchy and the aspect-operator hierarchy:

¹¹ That is, a well-formed MRS will be generated using the present tense, but the interpretive component or the pragmatics can only give it the force of a ‘hot news’ or ‘vivid narrative’ interpretation.

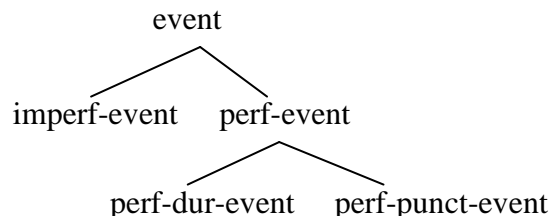


Figure 12: Updated event variable type hierarchy

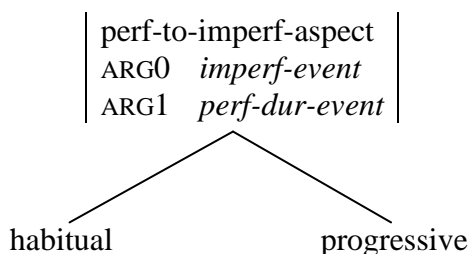


Figure 13: Updated aspect-operator hierarchy

It will be noted that the three classes of event variables correspond to three of Vendler's action types. The imperfectives are the statives, the perfective duratives are the activities, and the perfective punctuals are the achievements. From here on, I will use the terms 'stative', 'activity' and 'achievement' to refer to the event variable types and, when there is no danger of confusion, to the verbs which are lexically associated with those types.

I have not posited a type that corresponds to accomplishments. Accomplishments are essentially activities that have a natural ending point. Classical examples of the difference between activities and accomplishments include sentence pairs like (145) and (146).

- (145) John pushed the cart.
 (146) John pushed the cart to the store.

Sentence (145) is an activity. There is no condition that must be met in order for it to be complete – the activity is over whenever John stops pushing the cart. On the other hand, sentence (146) is an accomplishment. It is not a complete pushing-the-cart-to-the-store event until the cart is at the store. Another way of saying this is that an event of pushing-the-cart-to-the-store entails a resulting state of the cart being at the store.

It goes beyond the scope of this thesis to present an account of how this entailment arises, but I will point out how the approach to aspectual operators outlined here resolves the imperfective paradox (Dowty 1979). Dowty pointed out that although a sentence like (146) entails that the cart is at the store, the progressive version of the sentence, shown in (147), does not carry such an entailment.

- (147) John was pushing the cart to the store.

In (147), John may have stopped before actually getting to the store, but the sentence can still be true. Dowty's solution to this problem is to posit a branching time structure, where in the time branches that represent the typical course of events (however that is to be defined), the cart does end up at the store. But it is always possible that in the time branch that corresponds to the actual course of events, things go differently.

In my system, the problem doesn't even arise. The MRS for (146) and (147) are shown in (148) and (149).

- (148) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge push\text{-to-the-store}(e_1, JOHN, THE\ CART)\}, \{h0 =_q h1\} \rangle$,
 (149) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge progressive(e_1, e_2, h2), h2:push\text{-to-the-store}(e_2, JOHN, THE\ CART)\}, \{h0 =_q h1\} \rangle$

In (148), there is an explicit existential quantification on the event e_1 , which is an event of John pushing the cart to the store. This triggers the accomplishment's entailment, allowing us to infer that the cart got to the store. But in (149), there is no existential quantification on event e_2 . That is, there is no actual event of John pushing the cart to the store. Semantically, e_2 is being used to define the event *kind* of John pushing the cart to the store. The event e_1 , which is the progressive expression of the event kind defined with e_2 , is the only actual event being mentioned. This event carries no entailment.

Iterative

Now that we have made a type distinction between durative and punctual events, we have the opportunity for a new class of aspectual operators. That is, operators that relate achievements to activities. One such operator is *iterative*. So for instance, *tap* is an achievement. But in English, the iterative operator can be used without any accompanying morphosyntactic structure. So a sentence like (150) is ambiguous between the readings (151) and (152).

- (150) Herman tapped the window.
 (151) $\langle h0, \{h1:etime(e, t_R[TENSE\ past]) \wedge tap(e, HERMAN, WINDOW)\}, \{h0 =_q h1\} \rangle$
 (152) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge iterative(e_1, e_2, h2), h2:tap(e_2, HERMAN, WINDOW)\}, \{h0 =_q h1\} \rangle$

In addition, the activities created by the iterative operator are free to participate in the habitual and progressive operators. So sentences (153) and (155) can get the MRS structures in (154) and (156), respectively.¹²

¹² In fact, the achievement verb *find* could in principle participate in these operators as well, rendering (141) and (143) grammatical. This is pragmatically odd, however, as once the raisins are found, there is an expectation that they will not (need to) be found again.

- (153) Herman taps the window.
 (154) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge habitual(e_1, e_2, h2),$
 $h2:iterative(e_2, e_3, h3), h3:tap(e_3, HERMAN, WINDOW)\}, \{h0 =_q h1\}\rangle$
 (155) Herman is tapping the window.
 (156) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge progressive(e_1, e_2, h2),$
 $h2:iterative(e_2, e_3, h3), h3:tap(e_3, HERMAN, WINDOW)\}, \{h0 =_q h1\}\rangle$

In each of these cases, the variable e_1 is a stative, the variable e_2 is an activity, and the variable e_3 is an achievement.

Arguments Change Event Type

I have said that verbs are associated lexically with their event types. But the type of the event can, at times, seem to change depending on whether the verb has an object, or what kind of object it is. For instance, although *tap the window* is an achievement, *tap all the windows* is an activity. That is, sentence (157) doesn't seem to need an iterative operator; no window need be tapped more than once for it to make sense.

- (157) Herman is tapping all the windows.

I don't have a complete answer for this, but here is the outline of a possible approach. Notice that, even disregarding any iterative readings, sentence (158) is scopally ambiguous. Its MRS is given in (159)

- (158) Herman tapped all the windows.
 (159) $\langle h0, \{h1:etime(e, t_R[TENSE\ past]) \wedge tap(e, HERMAN, x), h2:every(x, h3, h4),$
 $h5>window(x)\}, \{h0 =_q h1, h3 =_q h5\}\rangle$

The event variable e is implicitly quantified, but in principle, either the variable x can outscope e , indicating that there was a different tap for each window, or e can outscope x , indicating that Herman somehow managed to tap all the windows with a single tap. In the first case e behaves like an activity. In the second case, e behaves like an achievement. So (157) can do without an iterative operator only if x takes wide scope. In readings where e takes wide scope an iterative interpretation is forced.

One approach is to underspecify *tap*'s event variable in the lexicon. That is, associate *tap* with an event variable of type *perf-event*. Further constraints would be needed to enforce that one or the other subtype be allowed in various scoping configurations. This has to be sensitive to many factors. For instance, it is not the case that activity variables must always be outscoped by some other variable – only those in the *tap* class. Also, *tap* variables remain achievements even if they are outscoped by another variable, if that variable is introduced in the subject of the sentence. In (160), the event is an achievement even if there is a different tapping event for each person.

(160) Every person tapped the window.

For now I will leave this and similar questions as open issues.

6.2 *Perfect vs. Non-perfect*

Comrie characterizes the perfect aspect as the present relevance of a past situation. Compare, for instance, sentences (161) and (162).

(161) I lost my wallet.

(162) I have lost my wallet.

Sentence (161) just says that there is an event, which happened during the (past) reference time, of me losing my wallet. On the other hand, (162) says something about the present time. That is, things are in a state which is the result of my having lost my wallet. Perhaps that state is that I still cannot find my wallet. Perhaps it is simply that I have had the experience of losing my wallet, and now I can sympathize with others who lose theirs. Pragmatics, rather than semantics, determines what the resulting state is.

My approach to representing this difference includes the assumption that all states are associated with two achievements: one that kicks it off, and one that finishes it. And similarly, each imperfective event (achievement or activity) is associated with two states: the one that holds before the event, and the one that holds after it. Thus, temporal reality, as conceived in language, consists of multiple strings of states punctuated by achievements and activities. Activities themselves can be viewed as states (via the progressive operator), and thus have a pair of bounding achievements as well. Below is a partial diagram of some of the events involved in me losing and finding my wallet.

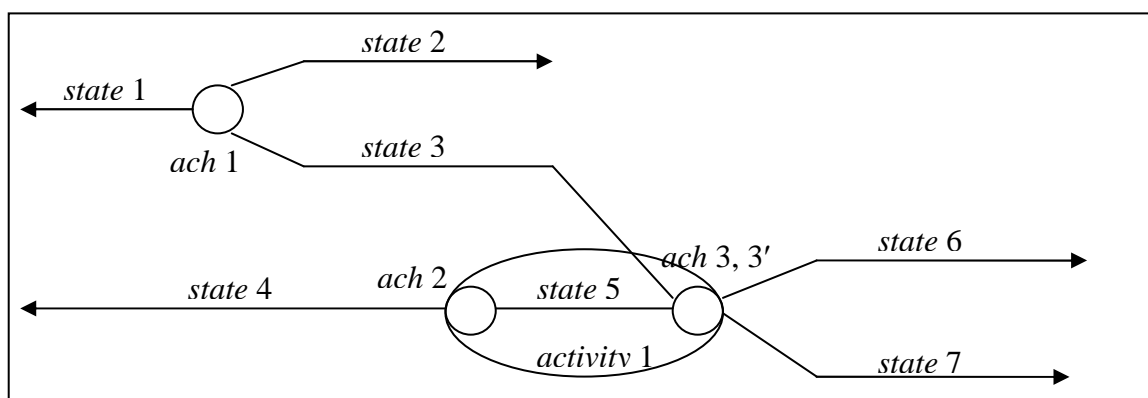


Figure 14: Partial temporal diagram for losing a wallet

This diagram consists of seven states, three achievements, and 1 activity. States are represented by line segments, and perfectives (activities and achievements) are represented by ellipses. State 1 is the state of me having my wallet. This state ends in achievement 1, which is me losing my wallet. Achievement 1 kicks off two new states.

State 2 is me having the experience of losing my wallet; state 3 is me not having my wallet. State 4 is the state of me not looking for my wallet. This state ends in activity 1, me looking for my wallet. Activity 1 is bounded by two achievements. Achievement 2 is me starting to look for my wallet; achievement 3 is me finding my wallet. Actually, there is also an achievement 3', me stopping looking for my wallet. State 5 is the state of me being in the process of looking for my wallet. The resulting state from achievement 3 is state 6: me having my wallet. The resulting state from achievement 3' is state 7: me not looking for my wallet.

This view of the world supplies us with more possibilities for aspectual operators. For instance, we now have available the operator *result*, which relates a state to the (perfective) event-kind that kicks it off. For instance, the MRS for sentence (162) would be something like (163).

$$(163) \langle h_0, \{h_1:etime(e_1, t_R[TENSE\ present]) \wedge result(e_1, e_2, h_2), \\ h_2:lose(e_2, I, WALLET)\}, \{h_0 =_q h_1\} \rangle$$

Here, e_2 is the me-losing-my-wallet kind of achievement. The *result* operator relates it to e_1 , the state that results from e_2 .

Notice here that what was good for the *progressive* operator appears to be not so good for the *result* operator. There is no entailment in (163) that any losing achievement actually took place, although (162) certainly does have such an entailment. There are two possibilities for dealing with this. First, we can just stipulate somewhere that the *result* operator adds the entailment that there is some instance of the event-kind it references that actually exists. The other possibility is that *result* isn't an operator at all, and in fact the correct MRS for sentence (162) looks like (164).

$$(164) \langle h_0, \{h_1:etime(e_1, t_R[TENSE\ present]) \wedge some(e_2, h_2, h_3), h_4:result(e_1, e_2), \\ h_5:lose(e_2, I, WALLET)\}, \{h_0 =_q h_1, h_2 =_q h_4\} \rangle$$

Here, the MRS explicitly existentially quantifies the wallet-losing event, and relates that quantified event to the present tense state e_1 . But notice that there is nothing in (164) that cannot be recovered from the information in (163). So while it is still an interesting semantic question of which form to ultimately use for interpretation, for the purposes of simply generating the MRS representation, I will assume representations such as the one in (163).

We can tell that the perfect operator *result* returns a state, not just because of our intuitions about what a sentence like (162) means. Perfect sentences are just fine in the present tense, a mark of stative events. Also, a state cannot undergo operators such as *habitual*, *progressive* or *iterative*, as indeed perfects cannot. In English, the habitual and iterative aspects are not marked by morphosyntactic structure, so we still have to rely on our intuitions. But we can tell by the ungrammaticality of (165) that the result of the perfect cannot undergo the progressive.

(165) * I am having lost my wallet.

I have claimed that only perfective events (activities and achievements) can undergo the perfect. This follows from the assumption I made above about the punctuated-stative nature of the world, as conceived in language. This seems to be borne out by (166) through (168).

(166) I have found the raisins.

(167) I have eaten the raisins.

(168) ? I have liked raisins.

Note also that this analysis predicts that you cannot get the perfect of a perfect, which is borne out by (169).

(169) * I have had lost my wallet.

However, this also predicts that sentences like (170) are ungrammatical:

(170) I have been in my office.

The phrase *be in my office* is a stative. How is it that it can undergo the perfect, but other statives, in particular the result of a stative, cannot? First, notice that (170) really only makes sense if I have already left my office. My explanation is that an additional operator, which takes a state and returns a perfective event, is at play here. This could be either an “anti-progressive” operator that takes a state and returns an activity, or an operator that takes a state and returns the achievement that ends it. Either way, the perfective version of the state of me being in my office is followed by my no longer being in my office. Sentence (170), under this analysis would get the MRS in (171).

(171) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge result(e_1, e_2, h2),$
 $h2:state-to-perf(e_2, e_3, h3), h3:occupy(e_3, I, OFFICE)\}, \{h0 =_q h1\} \rangle$

But if (170) can be saved by the introduction of an operator (unaccompanied by any morphosyntactic structure), why can't (168) or (169)? Actually, (168) *can* be saved this way, it is just that the result is pragmatically odd. It really only makes sense if your feeling about raisins have changed, and it is currently significant that you once liked them. Both of these things seem unlikely. I'm not really sure what to say about (169). Perhaps it is just a syntactic fact about English that we cannot have a perfective of a perfective.

Comrie notes that various languages make various distinctions among different kinds of perfect. Kpelle makes a distinction between the ‘perfect of result’ and the ‘experiential perfect’, so we have these sentences:

(172) ɲââ `kpetɛ.

(173) ɲà `kpetɛ.

They both translate to English *I have fixed it*. But (172) indicates that it still works (perfect of result), where (173) could be used to show that I have experience in fixing it (so now that it is broken again, I would be a good person to look at it). Divisions such as these can be accommodated by positing subtypes of the *result* operator.

Related Aspects

The perfect operator *result* is not the only one that our perfective-imperfective assumption predicts. There should also be an ‘anti-perfect’ operator: one that goes from a state to the achievement that kicked it off. This is the operator used for inceptive aspect. Comrie notes that in Mandarin Chinese, the Perfective morpheme can have this meaning:

(174) t̄ā gāo-le.
he tall-Pfv.
‘He became tall.’

(175) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge inceptive(e_1, e_2, h2), h2:tall(e_2, HE)\}, \{h0 =_q h1\} \rangle$

The variable e_2 together with $h2$ is the state kind of him being tall; e_1 is the achievement of him becoming tall.

We also expect an operator that goes from a state kind to the achievement that finishes it. This is the operator used for the cessative aspect.

(176) Terry left the office.
(177) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge cessative(e_1, e_2, h2), h2:occupy(e_2, TERRY, OFFICE)\}, \{h0 =_q h1\} \rangle$

The variable e_2 is the state kind of Terry being in the office; e_1 is the achievement of leaving the office.

We expect the inceptive and cessative operators to have versions that go from an activity (rather than a state) to the achievement which begins or ends it, or versions where the operator can take either an activity or a state into an achievement.

Finally, there should also be an operator that goes from a perfective to the state that precedes it. This is the operator used for the prospective aspect.

(178) Terry was going to eat the cookie.
(179) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge prospective(e_1, e_2, h2), h2:eat(e_2, TERRY, COOKIE)\}, \{h0 =_q h1\} \rangle$

The variable e_2 together with $h2$ is the achievement type of Terry eating the cookie; e_1 is the state that leads up to the eating. Note here that there is no entailment that Terry actually eats the cookie. The variable e_2 is not bound by any existential quantifier – just by the prospective operator. We are in the state that precedes the eating of the cookie, but it is still possible for things to change before the cookie actually gets eaten.

6.3 Operators or Features?

I have proposed a relatively elaborate account of aspect, positing sequences of aspectual operators for aspectually complex sentences. Wouldn't it be possible to represent the information implicitly in a set of features on event variables, and let subsequent processing interpret those as appropriate? For instance, sentence (155), repeated here as (180), has the MRS in (156), repeated here as (181). But this doesn't contain any information that couldn't be recovered from an MRS like (182). Couldn't we just use the simpler representation?

- (180) Herman is tapping the window.
 (181) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge progressive(e_1, e_2, h2),$
 $h2:iterative(e_2, e_3, h3), h3:tap(e_3, HERMAN, WINDOW)\}, \{h0 =_q h1\} \rangle$
 (182) $\langle h0, \{h1:etime(e[PROG\ +, ITER\ +], t_R[TENSE\ present]) \wedge$
 $tap(e, HERMAN, WINDOW)\}, \{h0 =_q h1\} \rangle$

There are a number of reasons why we may not want to abbreviate aspectual operators using features. Binary features can't support multiple occurrences of the same operator. The operator approach predicts that there could be a language that grammaticizes a sentence with a meaning such as (183), giving an MRS like (184).

- (183) Terry began the process of continually starting to read *Moby-Dick*.
 (184) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge inceptive(e_1, e_2, h2),$
 $h2:iterative(e_2, e_3, h3), h3:inceptive(e_3, e_4, h4),$
 $h4:read(e_4, TERRY, MOBY-DICK)\}, \{h0 =_q h1\} \rangle$

Here, Terry keeps starting to read *Moby-Dick*. MRS (184) indicates that this process began during the (past) reference time. The variable e_4 with handle $h4$ is the activity kind of Terry reading *Moby-Dick*. The variable e_3 with handle e_3 is the achievement kind of Terry starting to read it. The variable e_2 with handle $h2$ is the activity of Terry continually starting to read it. The variable e_1 is the achievement of Terry beginning the activity of continually starting to read it. Using a set of binary features, there is no way to encode the fact that the inceptive operator has been used twice. It is true that we can simply add more features, such as DOUBLE-INCEPTIVE. However, if our hypothetical language grammaticizes inceptive through a suitably recursive mechanism, such as derivational morphology or auxiliary verbs, this approach will ultimately fail.

The more highly elaborated approach makes use of a sequence of operators, not just a set of them. It may not always be possible to reconstruct a single unambiguous order of operators from a set of features. For instance, there may be a language that grammaticizes a sentence with a meaning such as (185), yielding an MRS like (186).

- (185) Terry is going to stop her habit of entering the office.
 (186) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge prospective(e_1, e_2, h2),$
 $h2:cessative(e_2, e_3, h3), h3:habitual(e_3, e_4, h4), h4:inceptive(e_4, e_5, h5),$
 $h5:occupy(e_5, TERRY, OFFICE)\}, \{h0 =_q h1\}\rangle$

Here, e_5 with $h5$ is the state kind of Terry being in the office; e_4 with $h4$ is Terry entering the office, e_3 with $h3$ is Terry habitually entering the office, e_2 with $h2$ is Terry stopping the practice of entering the office, and e_1 is Terry being about to stop the practice of entering the office. The feature approach would have us represent this something like (187). But note that this is the exact same representation we would get for a sentence meaning (188), which should get the MRS in (189),

- (187) $\langle h0, \{h1:etime(e[PROSP +, CESS +, HABIT +, INC +], t_R[TENSE\ present]) \wedge$
 $occupy(e, TERRY, OFFICE)\}, \{h0 =_q h1\}\rangle$
 (188) Terry is in the habit of beginning to be about to leave the office.
 (189) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ present]) \wedge habitual(e_1, e_2, h2),$
 $h2:inceptive(e_2, e_3, h3), h3:prospective(e_3, e_4, h4), h4:cessative(e_4, e_5, h5),$
 $h5:occupy(e_5, TERRY, OFFICE)\}, \{h0 =_q h1\}\rangle$

Of course, these arguments would carry more force if I could actually produce such sentences in some language. Until such sentences are produced, or somehow shown not to exist, this stands as differing predictions made by each approach.

Aspectual operators can constrain their arguments to be of particular types. This is how we have accounted for the ungrammaticality of, for instance, (190) and (191), and why we do not, for instance, get a habitual reading for (192) and (193). The *progressive* and *habitual* operators take activities. The event for the verb *like*, and the output of the *result* operator are both states.

- (190) * Harriet was liking raisins.
 (191) * I am having lost my wallet.
 (192) Harriet likes raisins.
 (193) I have lost my wallet.

No doubt, there are other ways to rule out these sentences, or these readings for these sentences, but with the operator approach, we can do this quite straightforwardly using the typed feature-structure framework.

Finally, the operator approach must be used if we need to be able to refer to each of the event arguments separately elsewhere in the grammar. This is precisely what we

need in order to account for the distinct (iterative) readings of (194), shown in (195) and (196).

- (194) Herman tapped the window to get Terry's attention.
 (195) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge iterative(e_1, e_2, h2) \wedge to_get_attention(e_1), h2:tap(e_2, HERMAN, WINDOW)\}, \{h0 =_q h1\} \rangle$
 (196) $\langle h0, \{h1:etime(e_1, t_R[TENSE\ past]) \wedge iterative(e_1, e_2, h2), h2:tap(e_2, HERMAN, WINDOW) \wedge to_get_attention(e_2)\}, \{h0 =_q h1\} \rangle$

In (195), the thing that Herman did to get Terry's attention was to tap the window repeatedly. In (196), what Herman did repeatedly was to tap on the window, trying to get Terry's attention each time. In a feature-based approach, there is no way to distinguish between these two readings.

One possible response is to say that the feature-based representation is underspecified, and that the interpretive component will associate it with separate readings that correspond to (195) and (196). This won't do, however. The feature-based approach would presumably give a representation to (197) which is the same, in relevant ways, to the one it gives to (194).

- (197) To get Terry's attention, Herman tapped the window.

However, (197) only has the reading in (195), not the reading in (196). From this, I conclude that the distinct events assumed by the operator approach are necessary.

6.4 Summary

In this section I have laid out my proposal for handling aspect in MRS. Aspectual operators relate events to event kinds. For instance, the *habitual* operator relates a stative event to the activity-kind it is the habitual expression of. These operators may be introduced in any of the ways that an EP may be introduced, but they are commonly introduced via lexical rules, possibly without any morphological change between the input form and the output form. Since events in various aspects are expressions of event kinds, and those kinds are not required to have any instances that actually exist, this provides a resolution to the imperfective paradox.

Operators are implemented in MRS as predicates with three arguments: two event variables and a handle. The second event variable and the handle together define the event type. The handle is not related to an EP label via a $=_q$ constraint; it is identical to the label of some EP in the MRS.

I split the *perfective* event type into two subtypes: *punctual*, which corresponds to achievements; and *durative*, which corresponds to activities. The *progressive* and *habitual* operators relate activity event kinds to imperfective events. The *iterative* operator relates achievement event kinds to activity events. Aspectual operators can be strung together to turn event kinds of one sort into event kinds of another sort, and eventually to events of still another sort.

The conception of the temporal arrangement of events where statives are bounded by perfectives, which in turn are flanked by statives, gives rise to another set of aspectual operators, typified by the perfect, which relates an achievement (kind) to the state that results from that achievement.

7 CONCLUSION

In this thesis I have presented and argued for an approach to tense and aspect within the framework of Minimal Recursion Semantics. In this approach, certain lexical items, namely verbs and (at least) some nouns and adverbials introduce EPs that include an unbound time variable as one of its arguments. The contribution of tense is to specify the value of a TENSE feature on this time variable. In the final interpretation of the MRS structure, some time will be associated with this time variable, and that time must be compatible with the constraint imposed by the TENSE feature. In this approach, event variables are divided into a number of types. The type of the event variable determines the nature of the relation between the event variable and its reference time. Perfective events occur within their reference times and imperfective events surround their reference times. Aspectual distinctions are accounted for with aspectual operators, which relate event variables to other event variables. These operators constrain the types of event variables that can appear as their arguments.

In order to provide a full semantic account of tense and aspect, I have proposed a novel approach for determining the model-theoretic interpretations of MRS structures directly. In this account, models contain hypotheses, which taken together correspond to every thing that might be given a truth value. The model specifies which of these hypotheses is true. Hypotheses concerning quantification involve relations between kinds, which are stored in the model along with normal individuals. Aspectual operators also involve relations between event individuals and event kinds. Although I have every reason to believe this approach to semantics could be made to work for interpreting syntactic structures directly, it is particularly applicable for the interpretation of semantic representations, such as MRS, where quantifiers and other scopal operators are treated as a variety of predicate.

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