

A Semantics for Temporally-dependent Referring Expressions

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In this paper, we sketch a new approach to the problem of the temporal interpretation of nominal predicates. The approach differs from previous analyses (e.g., Enç (1986), Musan (1999), Tonhauser (2002)) in that it is grounded in a different ontology, namely one that regards individuals as spatio-temporal entities (a.k.a. ‘spatio-temporal worms’) (Heller (1990), Sider (1997), *inter alia*): roughly, the idea is that individuals have temporal parts (or stages) —and are indeed like events, for that matter— in the same way they have spatial parts. As we will show, this view, known in the philosophy literature as *four-dimensionalism*, has interesting repercussions for formal semantics in general, and for the formal treatment of temporal NPs in particular.

1 Background on temporal NPs

1.1 The problem

The task of computing the temporal interpretation for a natural language utterance is often taken to be a fairly simple matter. That is, computing the temporal interpretation for an utterance would basically boil down to giving a temporal interpretation to its verbal predicate, or, to be more precise, to its inflected projection. A direct consequence of this view is that all the other predicates present in a sentence, including nominal predicates (but also, as we shall discuss adjectival and prepositional ones) are implicitly taken to be atemporal. Thus, asked to give a logical form for a sentence like (1) an intro-to-semantics student is most likely to produce something like (2) —where x ranges over the domain of individuals, t over the domain of time instants, and ‘<’ stands for temporal precedence:

(1) A man snored.

(2) $\exists x, t (man(x) \wedge snore(x, t) \wedge t < now)$

In the logical representation (2), the only thing that is located in time is the property ‘snore’ expressed by the verbal predicate *snored*: it is located at some time prior to the utterance time (symbolized here by *now*); and we know this thanks to the past morphology carried by the verb.

A couple of things are missing from the logical form above. For one thing, one has no indication regarding the precise domain of quantification. Secondly, and more importantly to our present concern,

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the representation in (2) says nothing about *when* the nominal predicate in this restrictor has to be true of the quantified-over individuals (i.e., when these individuals belong to the class of men). This question, of course, makes little sense when talking about properties such as *man* (i.e., leaving aside sex change operations, men are always men as long as they are alive). But consider examples like (3) and (4):

(3) Every art student visited the MoMA.

(4) President Bush will receive the hostages at the White House.

Properties such as ‘art student’, and ‘hostage’ have clearly not the same flavor as ‘man’: roughly speaking, the latter property is permanent, whereas the latter are transient (well, hopefully). Different names have been offered in the linguistic and philosophical literature to capture this distinction (e.g., Carlson’s individual-level vs. stage-level predicates Carlson (1980) or Wiggin’s substantial vs. non-substantial distinction Wiggins (1980)).

1.2 Existing accounts

The fact that some properties do not hold permanently of individuals raises the question of their temporal interpretation (i.e., of when they can be predicated of the individuals). The null hypothesis is to consider that the properties expressed by the predicates present in a sentence are dependent upon the time given by the verbal inflection. This line of research has been both pursued and rejected by Mürvet Enç (see Enç (1981), Enç (1986)). In her discussion, Enç first assumes that tense morphology gets translated into the Priorian modal operators **P** (for Past) and **F** (for Future) that take scope over the sentence. In its most naive form, this hypothesis then predicts that the different predicates in a sentence are interpreted at the verbal time (i.e., they are in the scope of the tense operator). For sentence (3), this approach yields a reading where the two predications ‘visit-the-MoMA’ and ‘be-an-art-student’ are true at the same time of a (contextually restricted) set of individuals; that is, roughly, these individuals are art students when they visit the MoMA. It is easy to see that this analysis is at best incomplete. For there is another possible reading for sentence (3), one that one could paraphrase as follows: every *current* art student visited the MoMA. There is of course a nice way to capture this second reading, namely to assume that NPs are able to raise out of the scope of the past operator and are interpreted at utterance time.¹ But this cannot be the whole story, as was noted by Enç. Thus, sentence (3) has probably a third (mixed) reading under which all past *and* present art students made the visit to the MoMA. Crucially, a quantifier-raising analysis breaks down on this kind of example, since one would in effect need the predicate *student* to be at the same time out of the scope of the past operator (to get the current students) *and* in its scope (to get the former students).²

Another problem, pointed out by Enç, with the assumption that the temporal interpretation of NPs depends upon that of the verbal predicate, is illustrated by example (4). To put it roughly, the problem is that, under the preferred reading for this sentence, the individuals picked up by the nominal predicate ‘hostages’ will have this property neither at the verbal predicate time, nor at the utterance time. Most likely, the hostages we are talking about in (4) have been liberated at some point before the

¹This goes with the implicit assumption that there is an operator for the utterance time, higher up in the structure.

²Note that there is yet another, slightly more difficult to get reading for this sentence; namely one, where the individuals that visited the MoMA did not have the property of being students yet (i.e., they visited the museum before becoming art students.)

utterance time. The problem is simply that there is nothing in the sentence that can trigger this past interpretation. (Note that this example also shows that syntactic position is irrelevant to the problem of temporal NPs, since the NPs that has a ‘shifted’ interpretation is here in object position.)

1.2.1 Enç’s account

Given the above problems,³ Enç arrived at the conclusion that the temporal interpretation of NPs should be free from the operator given by the verbal inflection. More precisely, she argues that: (i) NPs like verbs should be given their own temporal argument, and (ii) this argument should be entirely resolved through context, so that a nominal can in effect refer to *any* set of individuals ((Enç, 1981, p.37)). To give an example, the logical form for sentence (3) will look like (5) —where the NP *MoMA* is treated as a constant, for simplicity:

$$(5) \quad \forall x[\exists t(\text{art_student}(x,t)) \rightarrow \exists t'(\text{visit}(x, \text{MoMA}, t') \wedge t' < \text{now})]$$
⁴

Opening a brief parenthesis here, note that ‘temporalizing’ nominal predicates the way Enç does (i.e., treating them like verbal ones by providing them, with a temporal argument) receives support from at least two sources. First, and this is well-known, nominals like verbs have temporal modifiers. In the nominal domain, we think of adjectives like *former*, *current/present*, *future*.

Furthermore, some adverbs can be used with both verbs and nominals (e.g., *in the eighties*, or even *then* as in *the then doctor*); this actually makes the term *adverb* somewhat of a misnomer for these modifiers are restricted to predicative categories (and not only to verbs). Second, it is also known that in some languages, nouns carry temporal morphology (see Sadler and Nordlinger (2001) for an overview).⁵

1.2.2 Some recent proposals

Enç’s claim above amounts, in effect, to saying that all NPs are *indexicals*; that is, the temporal interpretation of NPs is not constrained but by context. This very liberal view has been recently challenged in the literature. There are actually two main (and rather distinct) lines of criticisms. The first caveat, emerging from the work of Musan Musan (1999) is that not all NPs, according to her, are allowed to have an interpretation that is independent from that of the verbal predicate; that is, there is a class of NPs (so she claims) that would always be *temporally dependent*. According to Musan, this class consists of so-called *cardinal weak NPs* (i.e., NPs with determiners like *some*, *few*, *many*, *two* under their *cardinal reading*). Musan, following work by Milsark, opposes the cardinal reading of these quantifiers to their so-called *partitive reading*. This opposition can be viewed as follows: *partitive weak NPs* are *presuppositional* (i.e. roughly speaking, they have a hidden definite built into them), whereas *cardinal* do not. That is, the NP *some men* for instance, under its *partitive reading*, means *some of the men*, whereas this NP means roughly *a small number of men* under its *cardinal reading*.

³See Enç (1986) and Tonhauser (2000) for a more exhaustive survey of Enç’s arguments.

⁴Different interpretations will arise depending on the relation between t and t' .

⁵Sadler and Nordlinger (2001) actually distinguish between two phenomena. The first one, found in a language like Lardil (Australia), is where nominals carry temporal information that is relevant to the whole proposition. The second one, which is more directly relevant, is found in Tariana (Brazil): in this language, nominals carry information intrinsic to the NP itself.

Note that this claim is far from uncontroversial. Thus, Tonhauser (2000, 2002) rejects it altogether, arguing that even cardinal NPs can have a temporally independent interpretation⁶. The main example she proposes goes as follows:

(6) Context: at a reunion of the survivors of the Titanic disaster.

(7) Look, there are even *some crew members* here.

We do not think that this sort of examples constitutes a valid rebuttal of Musan's claim, for the NP in (7) does not qualify as a cardinal NP. This, we argue, because the head noun *member* has an implicit argument, which if not overtly realized has to be contextually 'bridged'. The most salient candidate for bridging is the definite NP *the Titanic*; this in effect means that the NP *some crew members* has an hidden definite (i.e., it means 'some crew members of the Titanic'), hence cannot be a cardinal NP.

Before we examine Tonhauser's proposal in more details, note that Musan's account contains another novelty that is worth mentioning here. That is, Musan notes that the question of interpreting NPs temporally also depends upon the type of nominal predicates we are dealing with, a point alluded to at the beginning of this introduction. In particular, she notes that NPs which realize an existence-independent argument of the verbal predicate will be temporally dependent/independent if and only if they quantify over stages/individuals. As we will see in the coming sections, a feature of the present paper will be to pay more attention to the different ontological categories of predicates, as well as to give them a proper formal representation.

The second line of departure from Enç's original account comes from Tonhauser (2000, 2002). To a certain extent, Tonhauser (2002) can be better viewed as a direct refinement of Enç's account, for this work proposes ways to constrain the interpretation of the temporal index associated with nominals. This account is couched in dynamic semantics, in DRT more precisely. The way Tonhauser proposes to 'tighten' Enç's account is by suggesting that, although nominals can receive various temporal interpretations given the appropriate context, they are *by default* interpreted at the same time as the verbal predicate. This claim is rather intuitive and allows Tonhauser to make some interesting predictions. Space precludes here to go over the formal details of Tonhauser's proposal. It will suffice here to notice that her DRT account comes with a number of minor problems. For one thing, her account predicts that plural entities should be alive at the same time, which cannot be right given that we have no problem to talk about entities like *Socrates and Russel*. Maybe even more problematic is the fact that Tonhauser fails to provide any substantial evidence as for why the verbal time should be the default interpretation for nominals. Thus, there are cases where it is the utterance time and not the verbal time that seems to serve as the default. A good example is, we think, given by possessives. The NP *my wife* as in, say, *My wife went to College at Yale*, has probably a first interpretation where the possessive relation holds true now.⁷ Note that we are not claiming here that the utterance time should now become the default interpretation, but rather that Tonhauser's starting assumption is highly questionable.

⁶Besides, De Cuyper (2002) indicates there may be more constraints on the possible readings, at least in the case of Dutch.

⁷Further argument for that claim maybe comes from the following minimal pair:

(8) My wife went to college at Yale.

(9) My *then* wife went to college at Yale.

Beyond the numerous objections and questions raised above, there is a more fundamental, *ontological* question; namely: What kinds of referents should be appealed to? What are nominals referring to? All three accounts discussed above are both rather elusive and conservative as far as ontology is concerned. Basically, they assume that (common) nouns, much in the same way as verbs, are now interpreted with respect to a temporal index; and the question of interpreting nominals roughly boils down to determining the relation between the temporal index of the noun and that of the verb. That is, the ontology is very ‘classical’, consisting of a single domain of individuals; the expressions denoting these individuals either remain atemporal (this is the case of proper names, for instance), or they can be ‘temporalized’ (i.e., be interpreted with respect to some temporal index). In this paper, we would like to take the idea of temporalizing nominals one step further, and this involves taking a different ontological stand. That is, we will investigate the consequences of recasting the problem of the temporal interpretation of nominals in a different ontological framework; namely, a framework where entities are no longer distinct from their (spatio-)temporal realizations, where objects (like events, for that matter) are no more than (spatio-)temporal regions (see also Carlson (1980)).

1.3 Plan of the paper

The rest of this paper will be divided as follows. In section (2), we describe in more formal detail the core of the proposal, along with its philosophical justifications. Section (3) briefly discusses how we capture, within our new ontology, the distinction between individual- and stage-level predication. In section (4), we consider in some details the consequences of our ontology on the syntax-semantics interface; we go in some detail through a number of concrete examples, emphasizing the new predictions. This section also discusses adjectival modification. Next, in section (5), we raise a number of open questions which might be handled by our account given some minor improvements; these include for instance questions regarding anaphora and predications types.

2 An Alternative Ontology

As discussed above, the solutions given in the literature to the problem of temporal noun phrases all involve providing nominals with an additional temporal argument. That is, this change remains rather minimal, in that it basically maintains the ontology commonly used by formal semanticists at least since Montague Grammar. This classical ontology, roughly, consists of the following basic elements:

- a domain of entities, D
- a domain for times (instants or intervals), T
- a domain for space, S
- (there might a domain of events, E , too)

Under this ontology, predicates are either atemporal, in which case they are sets of elements of D (e.g. proper names), or ‘temporalized’ (i.e., they have an argument slot for time), in which case they are sets of elements of $D \times T$. Under such a view, temporal effects are obtained through interpretation, as follows —where P is some binary predicate and *now* stands for time of utterance (cf. Musan (1999)):

(10) $\llbracket P(x,t) \wedge PAST(t) \rrbracket = 1$ iff x is $\in P$'s denotation at t & $t < \text{now}$

2.1 Problems with the ‘Classical’ Ontology

An apparent puzzle for this kind of account has to do with the fact that a lot of predicates (e.g., motion, spatial properties, ...) deal with questions of *material existence*; that is, they need to be related to the concrete referents in the world. A material referent can be viewed as a function $(D \times T) \rightarrow S$. This function has to be *partial*, since most things have only a limited life-span.

What this means is that when existence is necessary, it has to be stated explicitly in our logical forms. Put another way, one has to supplement the usual ontological framework with a predicate of existence-at-a-time (so that one is able to distinguish being ‘*not*(P) at t ’ with ‘not being at t ’).

This solution is illustrated on the following example:

(11) The King of France is bald.

The logical form for this sentence would be something like the following, where two different types of existence have to be postulated:

(12) $\exists!x(\text{king_of_france}(x) \wedge \text{bald}(x) \wedge \text{exists}(x, \text{now}))$

The classical ontology seems undesirable, for it commits us to two different kinds of existence: one logical rendered by the existential quantifier and one material rendered by an explicit *exists* predicate (see also Simons (1987)). This is indeed not very satisfactory from a metaphysical point of view.

To give another illustration of the problems faced by the ‘classical’ ontology, consider Geach’s well-known example:

(13) The ring is new but the gold it’s made of is old.

The problem with this type of examples is that we seem to make contradictory predications (new/old) over the same object. The solution provided in Link (1983) basically involved distinguishing an object from its substance or an object from the sum of its parts. Note that this solution basically builds upon the classical ontology. Thus, Link’s idea was to consider a function from the domain of objects to a domain of substances: *ring* and *new* are directly predicated of the object while *gold* and *old* are predicated of the object’s substance. The problem with this solution is that it is not clear at all that every object has a unique substance. Thus, different substances can be considered for the very same object. For instance, what is a snowman made of? Is it made of snow, of water, of molecules, or of atoms?

2.2 Entering the Fourth Dimension

To address these ontological problems, we take a different stand where instead of a separation between objects and their temporal or spatio-temporal extent, we assume the existence of objects within a unique spatio-temporal domain (the domain of all ‘histories’ of all material objects).

This alternative ontology, sometimes referred to as *four-dimensionalism*, has a long history and can actually be traced back to works by Russell, Whitehead (1929) and Quine (1960). These authors hold the view that every material object reduces to a spatio-temporal process. That is, everything is a spatio-temporal region (i.e., an ‘S-T event’ for Russell, a ‘worm’ for Quine). More precisely, this means that predicates hold of “stages”, and that persistent objects are mental reconstructions from perceptions of “reality”. Recently, ‘4-D’ has known somewhat of a revival through the work of philosophers like Heller, Noonan, and Sider (Heller (1990), Noonan (1976), Sider (1997, 2001)). In a similar vein than earlier studies, these studies describe entities we speak about as essentially temporal entities.

It is easy to see that an intrinsically temporal ontology like 4-D will have no problem with material existence or with object and substance(s). In the latter case, we don’t have to distinguish between objects and substances as different *a priori* types, but only between different spatio-temporal histories.

As far as we know, most of these ideas developed by four-dimensionalists (except, of course, for the distinction between entities and stages) and their implications for formal semantics have been so far overlooked by linguists. However, they seem to suggest a very natural revision of classical semantic interpretations,⁸ one that allows temporal relations on predicate arguments to be expressed.

2.3 More formally

In a temporal ontology for concrete objects, the domain of objects will be the set of all possible space-time histories, or space-time “worms”. Thus, the referent of, say ‘a dog’, will be all the positions the dog occupies in space-time during its lifetime. Now predicating something of that referent, e.g. that it ‘walked’ (treated here as another space-time worm), will amount to say that the intersection of the two worms is not empty. This is illustrated graphically in the Figure 1 below.

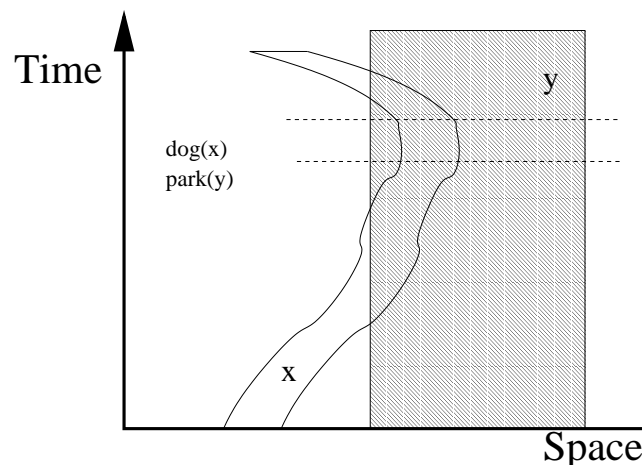


Figure 1: A dog (temporarily) walking in a park, in space-time.

Let us now look at the ontology more formally. First, let us call $\mathcal{M} = \langle E, \prec, \approx, \|\cdot\| \rangle$ a model and g be a variable assignment from D to $\wp(E)$, the power set of E , i.e. $g : D \rightarrow X \in \wp(E)$. These are such that:

⁸Such a revision is briefly alluded to in Carlson (1980).

- D is the set of variables of the language.
- E is a set of spatio-temporal "points" (the most fine-grained spatio-temporal events),
- \approx is a contemporaneity relation on spatio-temporal points
- \prec is a total linear ordering on classes of equivalence of E with respect to \approx .
- $\|\cdot\| \rightarrow \{0, 1\}$ is an interpretation function.

Note that a maximal set of contemporaneous points can be interpreted as an "instant".

The formal language also includes the relations ' $<$ ' 'is before', ' $stage$ ' 'is a stage of', ' \subseteq_t ' 'is temporally included in', which will be interpreted as follows:

- $\|x < y\|_g = 1$ iff $\forall \alpha \in \|x\|_g \forall \beta \in \|y\|_g (\alpha \prec \beta)$
- $\|x \subseteq_t y\|_g = 1$ iff $\forall \alpha \in \|x\|_g (\exists \beta \in \|y\|_g \alpha \approx \beta)$
- $\|stage(x, y)\|_g = 1$ iff $\|x\|_g \subseteq \|y\|_g \wedge \forall \alpha \in \|y\|_g [(\exists \beta \in \|x\|_g \beta \approx \alpha) \rightarrow \alpha \in \|x\|_g]$ ⁹
- in addition, the sum of objects ('+') is defined as set union: $\|x + y\|_g = \|x\|_g \cup \|y\|_g$.

We do not precise the model any further, since various properties could be discussed that are not necessarily relevant at this point. An axiomatization of a type of models where space is considered along with time in a same topology has already been proposed in Muller (1998).

Note finally that one might also want a model in which the other relations besides temporal ones are mereological. We will use a part-of relation, which could be interpreted in various ways, but formally corresponds to the following for now:

$$\|PART(x, y)\|_g = 1 \text{ iff } \|x\|_g \subseteq \|y\|_g.$$

3 Types of predication

In this section, we show how the different sorts of predicates are represented in the context of the above ontology.

If there is one ontological distinction between predicates that is well-known to linguists, it is undoubtedly the distinction between *stage-level predicates* and *individual-level predicates*. Very grossly, the distinction separates transient properties from permanent ones. The reason this distinction is so well-known to linguists is because many grammatical phenomena are sensitive to it (e.g., Milsark (1974), Carlson (1980), Rapoport (1991), Kratzer (1995)). We briefly look at three of these phenomena: bare plurals, English progressive, and secondary (depictive) predication.

Let's begin with the facts on bare plurals, first observed by Carlson (1980). Consider the two following sentences:

⁹We will thus assume that the *stage* relation is *reflexive* (i.e., anything is a stage of itself), *antisymmetric* (i.e., if x is a stage of y and y is a stage of x , then x and y are the same object), and *transitive* (i.e., if x is a stage of y , and y a stage of z , then x is also a stage of z).

(14) Phonologists are obnoxious.

(15) Phonologists are at the party.

There is a clear contrast between these two sentences. While the sentence featuring the stage-level (14) is ambiguous between a generic reading and an existential reading, (15) only has the existential reading.

Another well-known contrast comes from the English progressive. There, verbal stage-level predicates can be used with the progressive in English, whereas verbal individual-level ones cannot. This is illustrated with the following pair of examples:

(16) Jerry is smoking.

(17) *Jerry is knowing French.

Yet another grammatical reflex of this distinction comes from secondary depictive predication. As with the progressive, stage-level predicates but not individual-level ones are felicitous in this context (see, however, McNally (1994), for some counter-examples):

(18) Angelika gave the talk naked.

(19) *Angelika gave the talk intelligent.

Within the classical ontology, augmented with events, one way to capture the distinction between stage-level and individual-level predicates has been, following Kratzer (1995), to assume that the two types of predicates have a different argument structure. According to Kratzer, stage-level predicates bear a (neo-)Davidsonian argument, whereas individual-level lack such an argument. In effect, this makes stage-level predicates sets of events, while individual-level predicates remain sets of (tuples of) individuals. Under her account, the contrast between (18) and (19) is amenable to a simple arity explanation: a predicate like *intelligent* simply doesn't have an (event) argument, and so there is no event variable to be 'co-identified' with that of the VP *gave the talk*.

Note that Kratzer's proposal would make no sense, given our ontology. For this ontology starts with the assumption that is no distinction between individuals and events. In the context of four-dimensionalism, the distinction between stage-level and individual-level predicates will be captured as follows. The proposal is going to be very similar, at least in spirit, to Carlson (1980). Intuitively, a *stage-level predicate* is one that does not necessarily apply to the whole lifespan of an entity, but only to a part of that lifespan (e.g. *naked*, *student*). An *individual-level predicate*, by contrast, must be true at any time during an entity's lifespan (e.g., *intelligent*, *man*). More precisely now, we propose to capture the contrast as follows —where P_{stage} and P_{indiv} denote any stage-/individual-level predicate, and P'_{stage} and P'_{indiv} their respective denotations:

(20) $\llbracket P_{stage} \rrbracket = \lambda y [\exists x P'_{stage}(x) \wedge stage(x, y) \wedge x \neq y]$

(21) $\llbracket P_{indiv} \rrbracket = \lambda y [\exists x P'_{indiv}(x) \wedge stage(x, y) \wedge x = y]$

In words now, (20) says that P_{stage} only applies to slices of objects, whereas (21) says that P_{indiv} only applies to entire objects. Taking some concrete examples, now:

$$(22) \quad \llbracket student \rrbracket = \lambda y[\exists x \text{ student}(x) \wedge \text{stage}(x, y) \wedge x \neq y]$$

$$(23) \quad \llbracket man \rrbracket = \lambda y[\exists x \text{ man}(x) \wedge \text{stage}(x, y) \wedge x = y]$$

These denotations correctly capture the intuition that when we refer to an individual by calling him/her student, we are in fact only predicating over one slide of his/her history. By contrast, when we refer to an individual by calling him/her man/woman, we are predicating over his/her whole history.¹⁰

The next section will show in detail the predictions one obtains by using these denotations. As we will see there, the present account also provides a very natural explanation for the contrast between (18) and (19).

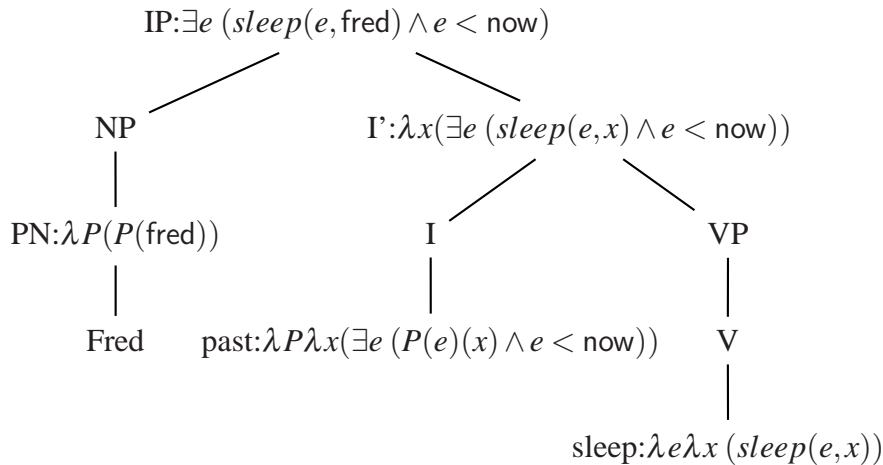
4 The syntax-semantics interface revisited

In this section, we consider the repercussions of using our new ontology on the syntax-semantics interface. We start by briefly considering the classical account.

4.1 The classical account

Below is the semantic derivation for the sentence *John slept*, under the ‘classical account’. In this account, close in spirit to Heim and Kratzer (1998) (augmented with events), NPs are functions ranging over sets of individuals (i.e., generalized quantifiers), while VPs are functions from events to functions over individuals. Inflections, finally, are functions from VP denotations to functions over individuals.

(24) Fred slept.



¹⁰Note that the denotations for verbal stage- and individual-level predicate will have to be slightly different from (20) and (21), for verbal projections combine with inflections. See next section.

4.2 Revisiting ...

The new ontology we are assuming gives a life-span to every object, therefore allowing it to be predicated over by temporal relations. More concretely, consider the revised denotations for the past inflection, the verb *sleep*, and the NP *Fred*:

- (25) a. $[\textit{past}] = \lambda Q \lambda x (\exists y Q(y)(x) \wedge y < \textit{now})$
 b. $[\textit{sleep}] = \lambda y \lambda x (\textit{stage}(y, x) \wedge \textit{sleep}(y) \wedge y \neq x)$
 c. $[\textit{Fred}] = \lambda P P(\textit{fred})$

These denotations do not seem to have changed drastically, but remember that we are now quantifying over a single and very distinct domain, namely a domain of spatio-temporal points. Note that there is a further revision regarding the denotation of the verb *sleep*, namely, the new denotation now explicitly encodes the fact that *sleep* is a transient property; i.e., in the present framework, it is a function ranging over stages.

Given these new denotations, the semantic composition yields the following logical form for the sentence *Fred slept*:

$$(26) [\textit{Fred}](\textit{past})(\textit{sleep}) = \exists y (\textit{stage}(y, \textit{fred}) \wedge y < \textit{now} \wedge \textit{sleep}(y) \wedge \textit{fred} \neq y)$$

That is, in words, *Fred slept* is true if and only if there is a (spatio-)temporal stage (distinct) of the entity *fred* in the past that also belonged to the sleep history (i.e., there was a sleeping episode in Fred's history).

In the following, we consider the amendments to be made to the denotations of the other parts of speech.

4.2.1 Nouns and quantifiers

We already discussed the denotations to give to stage-level and individual nominals in section (3); as in the classical account, noun denotations are very similar to those of (intransitive) verbs. Below are some other examples:

- (27) a. $[\textit{hostage}] = \lambda y (\exists x \textit{hostage}(x) \wedge \textit{stage}(x, y) \wedge x \neq y)$
 b. $[\textit{man}] = \lambda y (\exists x \textit{man}(x) \wedge \textit{stage}(x, y) \wedge x = y)$

That is, *hostage* holds of temporal slices of entities, while *man* assumes the whole history of the referred entity.

What is the denotation for quantifiers? Well, one can basically assume that quantifiers keep the same sort of denotations as in the classical account; e.g.:

$$(28) [a] = \lambda P \lambda R (\exists x (P(x) \wedge R(x)))$$

Given the above denotations, we are now in a position where we can derive semantic representations for sentences which involve multiple predicates like, say, *A man slept*—where we are temporally relating an individual-level nominal and a stage-level verbal predicate:¹¹

¹¹Note that the variables *e* and *x* will be used below for ease of notation, but it is worth remembering that these variables range here over the same domain (i.e., they don't have their usual implicit event and object interpretation).

$$\begin{aligned}
(29) \quad \llbracket A \text{ man slept} \rrbracket &= \llbracket a \rrbracket(\llbracket \text{man} \rrbracket)(\llbracket \text{slept} \rrbracket) \\
&= \exists x \exists s \exists s' (man(x) \wedge stage(s, x) \wedge s = x \wedge sleep(s') \wedge stage(s', x) \wedge s' < now \wedge s' \neq x) \\
&= \exists x \exists s (man(x) \wedge sleep(s) \wedge stage(s, x) \wedge s < now \wedge s \neq x)
\end{aligned}$$

Literally, *A man slept* is true if and only if there is a object that is a man and there is a sleeping stage as part of his history. Contrast the above representation with the one we get for the sentence *An hostage slept*—where we combine two stage-level predicates:

$$\begin{aligned}
(30) \quad \llbracket An \text{ hostage slept} \rrbracket &= \llbracket a \rrbracket(\llbracket \text{hostage} \rrbracket)(\llbracket \text{slept} \rrbracket) \\
&= \exists x \exists s \exists e (stage(s, x) \wedge hostage(s) \wedge s \neq x \wedge stage(e, x) \wedge sleep(e) \wedge e < now \wedge e \neq x)
\end{aligned}$$

The sentence *an hostage slept* is true if and only if there is an object x , such that this object has as part of its history both an hostage episode and a sleeping episode. Crucially, the temporal relation between these two episodes is left underspecified. This is correct since, as already observed, one might want $e \subset_t s$ (in which case x is an hostage during the time of the sleeping) or an empty temporal intersection: $e \cap_t s = \emptyset$ (in which case, x was no longer an hostage at the time of the sleeping). In other words, we leave it to the discourse context (rhetorical relations, maybe) to fill in the temporal relation between the two episodes in this case.

4.2.2 Universal quantification and the question of identity across time

Note that the present account has a potential problem with universal quantification. The problem is the following. Assume we simply ‘copy’ the old denotation of *every* into our account, i.e., we assume the following denotation:

$$(31) \quad \llbracket \text{every} \rrbracket = \lambda P \lambda Q (\forall x (P(x) \rightarrow Q(x)))$$

Recall that we are now quantifying over (spatio-)temporal slices of individuals. Consequently, what a phrase such as *every man* means in this context is roughly every temporal slice of an object with the property "man".

But this cannot be quite right. Consider the following sentence, along with its tentative logical form (leaving out tense):

$$\begin{aligned}
(32) \quad \text{a.} \quad & \text{Every man had one drink (only).} \\
\text{b.} \quad & \forall x (man(x) \rightarrow had_one_drink(x))
\end{aligned}$$

This formula does not quite give us what we want. For it seems that it allows us to quantify over slices of the same man. Indeed, "man" is an individual-level property, so every temporal slice of something that has the property "man" also has the property:

$$\forall x, y (man(x) \wedge stage(y, x)) \rightarrow man(y)$$

Let's say we have a man x ; from (32-b) we know he had one drink. Let's consider now two disconnected different stages x_1 and x_2 of the same man x : from (32-b) again, they each had one drink, so x actually had two drinks !

This suggests that *every man* should rather be interpreted *maximally* with respect to the context (i.e., we are quantifying over maximal slices); that is, one should instead assume the following logical form:

$$(33) \quad \forall x(\text{man}(x) \rightarrow (\text{has_one_drink}(x) \wedge \forall y [\text{stage}(y,x) \wedge \text{has_one_drink}(y)] \rightarrow x = y))$$

And we should change the semantics of *every* for

$$[\text{every}] = \lambda P \lambda Q (\forall x (P(x) \rightarrow (Q(x) \wedge \forall y [\text{stage}(y,x) \wedge Q(y)] \rightarrow x = y)))$$

A similar solution to this problem is informally suggested by Noonan (1976).

4.2.3 Adjectives and adjectival modification

Let us now turn to adjectival denotation and the thorny problem of adjectival modification. First, let us get the verb *be* out of the way. We will assume here that the denotation of this verb is simply the identity function:

$$(34) \quad [\text{be}] = \lambda P.P$$

Consider the following example:

$$(35) \quad \text{Olga went to the party sick/*Polish.}$$

As this example makes clear, *sick* and *Polish* are stage- and individual-level predicates, respectively. That is, in our framework, they receive the following distinct denotations:

$$(36) \quad [\text{sick}] = \lambda y \lambda z (\text{sick}(z) \wedge \text{stage}(z,y) \wedge z \neq y)$$

$$(37) \quad [\text{Polish}] = \lambda y \lambda z (\text{polish}(z) \wedge \text{stage}(z,y) \wedge z = y)$$

These are, *mutatis mutandis*, the same denotations as for verbal stage- and individual-level predicates. Rather unexpectedly, the semantic derivation for *Olga was sick* looks very similar to *Fred slept*; that is:

$$(38) \quad [\text{Olga was sick}] = [\text{Olga}]([\text{PAST}]([\text{be}]([\text{sick}]))) \\ = \exists s (\text{stage}(s, \text{olga}) \wedge s < \text{now} \wedge \text{sick}(s) \wedge \text{olga} \neq s)$$

Now, what about *Olga was Polish*?

$$(39) \quad [\text{Olga was Polish}] = [\text{olga}]([\text{PAST}]([\text{be}]([\text{Polish}]))) \\ = \exists s (\text{stage}(s, \text{olga}) \wedge s < \text{now} \wedge \text{polish}(\text{olga}) \wedge \text{olga} = s)$$

Now, notice that the above denotations make the prediction that *sick* and *Polish* cannot be conjoined—at least under standard coordination, i.e., where $[\text{and}] = \lambda P \lambda Q (\lambda \vec{x} (P(\vec{x}) \wedge Q(\vec{x})))$. The observation that stage-level predicate and individual-level predicate are hard to coordinate goes back to Vendler (1967) (it is also found in Larson (1998)). The reason why such cases of coordination are ruled out under our account is because they would simply yield a contradiction; e.g.

$$(40) \quad \# \text{Olga was sick and Polish}$$

would yield:

$$(41) \quad \exists s(s < \text{now} \wedge \text{sick}(s) \wedge \text{stage}(s, \text{olga})) \wedge s = \text{olga} \wedge s \neq \text{olga} \models \perp$$

It is worth noting here that the above explanation can be extended to the infelicitous cases of individual-level predicates in depictive predications, noted by Kratzer. Depictives as in *Angelica gave the lecture intelligent* can indeed be analyzed as a case of (generalized) coordination. Therefore, this sentence is out because *gave a lecture* and *intelligent* clash in the the same way as *sick* and *Polish*.

There is another prediction we get for free with our ontology; namely, asserting that a individual-level property no longer holds of an individual entails that this individual no longer exists. For instance, *Olga was Polish* has the implicature that Olga is dead:

$$(42) \quad \text{Olga was Polish/a woman} \Rightarrow \text{Olga is dead}$$

This is a consequence of our system, because then:

$$(43) \quad (s < \text{now} \wedge \text{polish}(s) \wedge \text{stage}(s, \text{olga}) \wedge s = \text{olga})$$

which is equivalent to:

$$(44) \quad \text{polish}(\text{olga}) \wedge \text{olga} < \text{now}$$

If Olga's history is in the past of the speech time, it means she's dead.

Let us turn to the case of ambiguous adjectives like *beautiful* noted by Larson Larson (1998). Under his account, these can be predicated of objects or events:

$$(45) \quad \text{Olga is a beautiful dancer.}$$

The two readings proposed by Larson are:

$$(46) \quad \begin{array}{l} \text{a. } \text{beautiful}(x) \wedge \text{olga}(x) \wedge \text{dancer}(x) \\ \text{b. } \text{olga}(x) \wedge (\forall e(\text{dance}(x, e) \rightarrow \text{beautiful}(e))) \end{array}$$

The way Larson proposes to produce these two readings is slightly *ad hoc*: it is based on the idea that during the composition, the variable introduced by adjective *beautiful* can either be 'co-identified' with the individual variable or with the event variable introduced by the nominal *dancer*.

Under our ontology, there is no difference between objects and events. So, we have to resort to some other explanation. (This explanation isn't yet totally worked out.) Within our semantics, it is reasonable to assume that the adjective and the noun each introduce a stage (since both *beautiful* and *dancer* denote transient properties). In turn, these two stages, as in the case of *the hostage slept*, can but need not to, refer to the same stage. That is, the two readings proposed by Larson are also predicted by our account:

$$(47) \quad \begin{array}{l} \text{a. } \dots \wedge \text{stage}(z, \text{olga}) \wedge \text{dancer}(z) \wedge \text{beautiful}(z) \\ \text{b. } \dots \wedge \text{stage}(z, \text{olga}) \wedge \text{dancer}(z) \wedge \text{beautiful}(\text{olga}) \end{array}$$

5 Open questions

A number of constructions are still out of the reach of the proposal made in this paper. In the following, we briefly review some of these problematic cases that we intend to address later.

5.1 More on Adjectival modification

Our major concern regards adjectival modification. As we noted above, we don't yet have a fully worked-out solution for the *beautiful dancer* examples. But there are many other puzzling examples. Consider first the followings:

(48) A hungry hostage attended the dinner.

This example is interesting because the different predicates in the NP are interpreted at different times. That is, roughly, the adjective *hungry* is interpreted at the verbal time, while *hostage* is interpreted at some previous time. Notice that this type of mismatch is beyond the scope of traditional accounts of adjectival modification; crucially, these assume that the nominal argument and the adjectival one are 'co-identified' (cf. Higginbotham (1985), Kratzer (1995)). It is worth noting that this type of mismatch does not seem incompatible with the present account, since more temporal structure has actually been built into lexical meaning. More work is however required to figure out how Adj and N should be composed. What already seems clear is that something like rhetorical relations might be needed to actually compute the temporal relation between the stages involved.

There seems to be a strong similarity between the above examples and depictives and absolutes, although the adjective is NP-internal (and not at the clause periphery). That depictive feel is reinforced by the following contrast:

(49) (50) An happy Olga entered the room.

(51) # A Polish Olga entered the room.

This contrast between stage- and individual-level is probably amenable to the same explanation as for the depictives.

Another case where there seems to be mismatch between syntax and semantics is with so-called *hypallages*; i.e., a figure where a predicate (typically, an adjective) modifies one noun syntactically but another noun semantically. Literary examples include the following:

(52) Darksome wandering by the solitary night [Angel Day]

(53) The knight raised a vengeful hand

But we have also managed to find real-life examples:

(54) We had a sad dinner.

(55) The house was sad, since Fido's death.

A question we leave here is: Is it hypallage or rather metonymy: i.e., *dinner* is used for the people attending it, and *house* for the people living in it.

The following contrast should also be explained:

(56) Tired, the boys didn't go to the party. (they didn't)

(57) The boys didn't go to the party tired. (they did)

In particular, one has first to explain how the predication in the 'dislocated' AP *tired* is related to the predication of the matrix clause. The interpretation for these examples suggests that the secondary predication is outside the scope of negation in the first example, but inside it in the second example. What is remarkable in the latter example is that it is the secondary predication *alone* that is negated (i.e., there is an implicature that the boys did go to the party).

5.2 Anaphora and predicate types

Beside adjectival modification, our plan is to go beyond sentences and also consider anaphora. As shown by the following examples, there seem to be interesting interactions between predicate types and anaphoric possibilities:

- (58) a. The man was drunk an hour ago. He is sober now.
 b. The man was drunk an hour ago. # He is a woman now.
 c. The drunk was sleeping. ? He is sober now.
 d. The man had an operation. He is a woman now.
 e. The drunk jumped into the pool. ? He is sober now.

These facts seem beyond the scope of dynamic semantics account, such as Kamp and Reyle (1993), Groenendijk and Stokhof (1991) or Asher and Lascarides (2003).

6 Conclusion

We started our study with some known problems related to the temporal interpretation of certain noun phrases, and the unpalatable properties of the ontological framework generally assumed to solve these problems. We have shown here how to consistently change an atemporal ontology into a temporalized one in order to deal with temporal aspects of the semantics of noun phrases. This ontology had been suggested in the past, but had never fully adopted and put to work in a semantic framework. This is an attempt to unify a few semantic problems related to predication over events and concrete objects. While there are still some aspects in need of a more precise analysis, we hope that this kind of approach is a promising, coherent path to deal with temporal side-effects of predications other than verbal.

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