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Abstract

In this report, we present an account of the semantics of the English temporal prepositions. The approach taken here stresses the limited range of expressive possibilities afforded by these words, and pays particular attention to the irregular interactions they exhibit with verb-tense and -aspect. A framework is developed within which the semantics of English temporal expressions can be couched, allowing the temporal prepositions to be grouped according to their 'temporal function'. A key finding of the report is that the eighteen temporal prepositions considered here express, between them, at most six distinct temporal functions.

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1 Introduction

Sentences involving temporal prepositions number among our simplest and most natural expressions of temporal location and extent:

(1) Angela worked on the letter *until* 10 o'clock

(2) Bill will post the parcels *by* 10 o'clock

(3) Charles has sent me email *within* the last 10 minutes.

Altogether, there are eighteen or so temporal prepositions in English, depending on exactly how you count them.[1] One of their noteworthy features is that, in general, they cannot be embedded one within the other. Thus

(4) Angela wasn't working on the letter *until* 10 o'clock *until* 10 o'clock

(5) Charles had sent me electronic mail *within* the last 5 minutes *until* 10 o'clock

count, for most competent speakers of English, as nonsense. Examples where two temporal prepositions work together, as in

(6) *In* five minutes, David will have been working in his office *for* 6 hours

are, as we shall see, the exception rather than the rule. This lack of iterative capability, combined with the limited number of temporal prepositions available to start with, suggests that the expressive power of the temporal preposition system is strictly limited. That is, within the space of logically possible assertions concerning the temporal distribution of states and events, prepositions give us access to only a very limited subspace. The main burden of this paper is to identify this subspace and to explain how, exactly, the English temporal propositions span it.

Three points about the scope of our enquiry. First, in charting the expressive resources which the temporal prepositions put at our disposal, we shall not consider sentences where some other expressive device is doing the lion's share of the work. For instance, the sentences

(7) For all times between now and 10 o'clock, there exists a time between that time and 10 o'clock at which Angela was not working on the letter.

(8) For all times between now and 10 o'clock, there exists a time no more than 5 minutes earlier than that time at which Charles sent me electronic mail.

[1] The temporal prepositions considered here are *until*, *since*, *by*, *during*, *over*, *for*, *in*, *within*, *at*, *on*, *from*, *between*, *through*, *throughout*, *upto*, *before*, *after* and *ago*. The last of these, *ago*, is normally classified as an adverb rather than a preposition, but, as we will see, fits neatly into the temporal prepositional system. There are a number of related prepositions such as *about* and *around* which can have a temporal function, but which we ignore here.

contain temporal prepositions; but it is the quantification that is the beast of logical burden here. To make our enquiry manageable, we will limit ourselves to the elementary sentences containing temporal prepositions. In particular, we will be avoiding those sentences involving negation or other Boolean connectives, conditionals, or where temporal prepositions appear within the scope of quantifiers. Hopefully, our approach can be extended to deal with more complex sentences.

Second, many English temporal prepositions double up as non-temporal prepositions (Lakoff [10], Rice [16]). For instance, *in*, *at*, and *over* are arguably primarily spatial in character, borrowing their temporal senses via some sort or analogy or metaphor.[2] But the psychosemantic relationships between the temporal, spatial and abstract senses of prepositions lie outside the scope of this paper, which concentrates on the narrower issue of accounting for the truth-conditions expressible by means of the temporal prepositions. Not that we are antipathetical to such enquiries. Perhaps our narrowly truth-theoretical account will help us better appreciate the relationships between temporal prepositions (or temporal *uses* of prepositions) and their non-temporal cousins.

Third, English imposes some rather asystematic restrictions on which prepositions go with various kinds of argument. For instance, we say *in the week* but *at the weekend*, *on Monday* but *in May* and so on. This phenomenon too has received attention in the literature (e.g. Brée [1], Brée Smit and van Werkhoven [2]), but we declare it to be outside the scope of this paper. Again, this is not to deny that such restrictions on prepositional usage are devoid of rhyme or reason, or that they tell us anything important about the conceptualizations underlying our temporal vocabulary. It is just that our interest is in the logical characteristics of temporal prepositions, rather than on the matter of which prepositions belong with which sorts of objects. Accordingly, we will duck these latter issues by concentrating in the sequel primarily on sentences where the arguments to temporal propositions are either clock times or durations measured in hours and minutes.

The plan of the paper is as follows. Sections 2 and 3 are concerned with setting up the general framework within which our analysis will be conducted. Section 4 then goes on to identify one group of expressive possibilities provided by temporal prepositions. Section 5 digresses to consider the treatment of the progressive aspect, and then sections 6, 7 and 8 consider further groups of expressive possibilities. The results of the paper are summarized in section 9.

2 Temporal functions

Consider the sentences:

(9) Bill posted the parcel between 9 o'clock and 10 o'clock.

(10) Angela worked on the letter from 9 o'clock until 10 o'clock.

[2]The temporal uses of these prepositions counts for only a small proportion of total usage. For detailed data see Brée *et al.* [3].

Sentence (9) reports an event—namely, Bill's posting the parcel—and locates that event as having occurred *sometime* within the interval [9:00,10:00]. Sentence (10) also reports an event—namely, Angela's working on the letter—but locates that event as having occurred *throughout* that interval.

Following common practice in semantics (e.g. Richards [17]), we take (9) and (10) to have, as significant constituents, the tenseless sentences

(11) Bill post the parcel

(12) Angela work on the letter

respectively, which receive truth-values relative to intervals of time. Thus (11) is true over an interval J just in case Bill posts the parcel over that interval; likewise, (12) is true over an interval J just in case Angela works on the letter over that interval, and so on. We will have more to say presently on what it means for a tenseless sentence to be *true over* an interval; but for the present, let us take this notion as given.

On this approach, it is natural to give the truth-conditions of (9) and (10) as, respectively:

(13) There exists an interval J wholly contained within the interval [9:00, 10:00], such that (Bill post the parcel) is true over J

(14) For all intervals J wholly contained within the interval [9:00, 10:00], (Angela work on the letter) is true over J.

And we might write these truth-conditions symbolically as

(15) $\exists J(J \subset [9{:}00, 10{:}00]$ & (Bill post the parcel)$(J))$

(16) $\forall J(J \subset [9{:}00, 10{:}00] \rightarrow$ (Angela work on the letter)$(J))$

thus viewing tenseless sentences as 1-place predicates whose arguments range over time intervals. To be sure, there are alternative approaches to the semantics of tensed sentences to the one taken here. [3] However, the basic framework adopted here should not necessarily be understood as a rejection of these alternatives. It is merely that we have to work within some framework or other, and ours, as we shall see, has the virtue of simplicity for the topic at hand. But we expect that the conclusions presented below can probably be translated—with varying degrees of effort—into the frameworks favoured by a number of approaches to natural language semantics. So, those who think they have an argument against the interval-based framework adopted here should be able to reformulate what they find in this paper in their preferred terms.

Generalizing our analysis of (9) and (10), the temporal prepositional constructions *between…and* and *from…until* can be seen as functioning so as to map a tenseless sentence ϕ onto the propositions:

[3] Some writers, for example, have taken tensed sentences to quantify over *events* (Davidson [4], Parsons [15]), or over events and *time-points*, depending on the type of sentence (Herweg [7]). And among those who adopt the interval-approach, there is sometimes disagreement on which intervals, exactly, given tenseless sentences should be evaluated at (see Lascarides [11], where the discussion hinges on just this question).

(17) $\exists J(J \subset [t_1, t_2] \;\&\; \phi(J))$

(18) $\forall J(J \subset [t_1, t_2] \;\rightarrow\; \phi(J))$

respectively, where t_1 and t_2 are the prepositional arguments.[4] We shall call forms (17) and (18) *temporal functions*—that is: functions by which an underlying tenseless sentence ϕ is mapped to a proposition. Our goal in this paper is precisely to specify the range of temporal functions which the prepositional system makes available.

The temporal functions (17) and (18) express restricted existential and universal quantification over intervals. That is, they have the *general forms*:

(19) $\exists J(J \subset I \& \phi(J))$

(20) $\forall J(J \subset I \rightarrow \phi(J))$

where I is a time interval determined (in these cases) by the arguments to the prepositions. We call temporal functions having form (19) *existential* temporal functions, and those having form (20) *universal* temporal functions. The interval I, over which the quantification ranges, we call the *reference interval* of the temporal function. As we shall see in the sequel, most temporal prepositions and prepositional phrases have temporal functions of one or the other of the forms (19) and (20). That is: most temporal prepositions function so as so map a tenseless sentence ϕ onto a proposition which says either that ϕ holds over *some* subinterval J of a given interval I, or that ϕ holds over *all* subintervals J of a given interval I. The temporal functions associated with these prepositions can be specified by supplying just two parameters: the quantificational type (existential or universal) and a way of determining the reference interval.

We have spoken of temporal prepositions in sentences such as (9) and (10) as performing the task of mapping the underlying tenseless sentences onto propositions. But of course (9) and (10) contain, in addition to prepositional phrases, a past-tense marker. Other sentences contain markers not only for tenses, but also for the perfective and/or progressive aspect.[5] And, as might be expected, these tense- and aspect-markers can also play a role in determining the temporal function by which a tenseless sentence is mapped onto a proposition. That is: temporal functions belong not really to prepositions, but rather, to prepositions acting in conjunction with tense, aspect and perhaps other factors besides. So we must take these factors into account in explaining how temporal prepositions help to specify temporal functions.

3 Evaluating Tenseless Sentences over Intervals

Parsons ([15], pp. 230 ff.) has criticized interval-based semantic theories for basing themselves on the sometimes unintuitive notion of an event's occurring *at* an interval—something which

[4] See section 7.2 for a complication regarding *between…until*.

[5] A terminological note on tense and aspect. Finite English verbs have one of three tenses: past, present and future; in addition, they have either perfective or non-perfective aspect, where perfective aspect is signalled by *have* plus the past participle. Accordingly, following the practice of many writers, we speak of what grammar books traditionally call the *perfect tense* as the *present perfective*, of what they traditionally call the *past tense* as the *past non-perfective* and of what they traditionally call the *pluperfect tense* as the *past perfective*.

we never speak of in ordinary conversation. Whether or not this criticism is entirely fair, we do certainly owe readers some explanation as to what sorts of intervals various tenseless sentences are supposed to be true at (or rather, true *over*, as we shall say). Consider, for instance, the tenseless sentence

(21) Angela write the letter.

Suppose Angela writes the letter in question, starting at 9:15, and finishing at 9:45. Then which intervals, exactly, do we want to say the tenseless sentence (21) is true over? Several answers look possible: just the interval [9:15, 9:45]; or perhaps any interval J contained in [9:15, 9:45]; or again perhaps any interval containing [9:15, 9:45]. Let us see if we can motivate an answer.

If Angela writes the letter starting at 9:15 and finishing at 9:45, then, after the event, the sentence

(22) Angela wrote the letter between 9 o'clock and 10 o'clock.

is true, whereas

(23) Angela wrote the letter between 9:20 and 9:40

is false. That is, we can sometimes make a *between*-sentence false by narrowing the gap between the arguments. Given the temporal function (17) suggested for *between…and* in section 2, it seems sensible to count (21) as being true over the interval [9:15, 9:45] and false over all subintervals. That would at least result in correct truth-values for (22) and (23) in the above circumstances.

But now consider the tenseless sentence:

(24) Angela work on the letter.

And suppose again that Angela starts working on the letter at 9:15 and keeps working on it until 9:45, at which point she stops. Then

(25) Angela worked on the letter between 9 o'clock and 10 o'clock

is true: Angela *did* work on the letter between the said times. Only this time, the sentence

(26) Angela worked on the letter between 9:20 and 9:40

is *also* true: Angela may not have (completely) *written* the letter between 9:20 and 9:40, but she did *work on* it between those times. So, the sentence (25) is not made false by narrowing the gap between the arguments of *between …and*. This observation suggests that we should count the tenseless sentence (24) as being true over the interval [9:15, 9:45] *and over all its subintervals*. For again, that would at least result in correct truth-values for (25) and (26) in the above circumstances.

Clearly, then, we need to draw a distinction between (tenseless) sentences such as (21) and those such as (24). At the bottom of this distinction seems to lurk the fact that—speaking loosely—the former reports a *completed* event whist the latter reports an *ongoing process*. Distinctions of this general kind are familiar and widely accepted in semantics, following

Vendler [18], who differented between the four *aspectual classes* of activities, achievements, accomplishments and states. Less widely accepted are Vendler's specific proposals as to the number and nature of the different aspectual classes. (See, for example, Herweg [7], and Lascarides [11], for their own treatments.) But for the purposes of accounting for the semantics of temporal prepositions, the following minimal distinction suffices.

We suppose that some tenseless sentences (intuitively, those such as (24) which describe 'ongoing' process- or state-types), have the property that whenever they are true over an interval I, they are true over every subinterval of I. We call these *non-completion sentences*. We suppose in addition that other tenseless sentences (intuitively, those such as (21) which describe 'completed' event-types), have the property that whenever they are true over an interval I, they are false over some subinterval of I. We call these *completion sentences*.[6]

A word is also in order about the status of interrupted events and states. Suppose David works on a paper for the ten minutes between 9:00 and 9:10, and again for the ten minutes between 9:50 and 10:00. Then the sentence

(27) David worked on the paper from 9 o'clock until 10 o'clock

is false, according to our intuitions and according to the semantics for *from…until* proposed in section 2. But what if David really does work from 9:00 to 10:00, except for a 5-minute coffee break around 9:30? If we are lenient and say that (27) is true, then the semantics presented above in (18) seem to have been falsified. If, on the other hand, we are strict and say that (27) is false, we might ask what happens if David, instead of stopping for 10 minutes to drink coffee, stops for 10 seconds to scratch his back—or for 1 second to blink? Surely we cannot declare (27) false on *these* grounds. And what does it mean, come to think of it, for David to work on the paper over *every* subinterval of [9:00, 10:00]—including intervals of duration 1 second?

The problem appears even more acute over a longer time-interval. Surely we can utter

(28) David worked on the paper from June until September

without wishing to imply that he worked Sundays, through his summer holidays and at night. Moreover, it does seem that, during this period, it would be quite acceptable to say

(29) David did not work on the paper from Monday until Wednesday, because the computer was down

without compromising the truth of (28) at the end.

Obviously, flexibility is called for. Exactly what sorts of breaks are allowed in an event or state before a *from…until*-sentence becomes false is not determined by the sentence itself; also in play are a host of pragmatic factors. What we must decide here is the sort of framework within which such flexibility might be accommodated. Our proposal will be to regard the

[6] Actually, (21) arguably satisfies the much stronger property that, if true over I, it is false over *every* subinterval of I; and this stronger requirement is sometimes proposed as a defining characteristic of certain aspectual classes (see Dowty [5], p.42). However, since nothing we say in the sequel will hinge on any tenseless sentences having this stronger property, we will not insist on it as a requirement for completion-sentences. But we do not mean to argue that there might be no other reason to define aspectual classes using this requirement; it is just that we do not need to refer to such aspectual classes here.

underlying tenseless sentence as multiply ambiguous between more or less strict readings. Thus, if we want to be lenient, we might interpret the tenseless sentence

(30) David work on the paper

as true over weekends, public holidays and nights, provided they fall within some interval during which the process of David's working on the paper is in progress. If, on the other hand we want to be stricter, we might interpret (30) as being false over weekend breaks, computer down-times etc. but true over coffee breaks, scratchings and blinkings, provided they they occur within some period (say, part of a working day) during which the process of David's working on the paper (in the stricter sense) could be said to be in progress. Stricter still, and we interpret (30) as false over coffee breaks, but true over some scratchings and blinkings, and so on.

So, we can account for the indeterminacy in the truth-conditions of sentences like (27)–(29) in terms of indeterminacy in the underlying tenseless sentences, whilst preserving a simple semantics for the temporal prepositions (and, hopefully, for other mechanisms for specifying temporal relations). On this approach, tenseless sentences like (30), if true over an interval I, really are true over every subinterval J of I, even if J falls within a break in the activity. If this consequence sounds counterintuitive, it oughtn't. We should be flexible on the the issue of whether our semantic theory takes (30) to be true over an interval. We should adopt the policy that gives us, overall, the simplest semantic theory that accords with our intuitions about the truth and falsity of ordinary English sentences.[7]

We now return to the main business of charting the temporal functions expressible by means of temporal prepositions.

4 The group-I temporal functions

In the previous section, we proposed that the temporal prepositions *between ...and* and *from ...until* should be seen as having temporal functions of the forms:

(19) $\exists J(J \subset I \& \phi(J))$

(20) $\forall J[J \subset I \rightarrow \phi(J))$

respectively, where I, the so-called reference interval, is fixed directly by the arguments to those prepositions. In this section, we examine a group of temporal prepositions which also express temporal functions of this form, but where the reference interval is fixed *indexically* or *anaphorically*.

[7]Hence we do not find it necessary to follow Vendler and others in distinguishing between *states*, which are true over all subintervals of any interval over which they are true, and *activities*, which are true over all sufficiently large subintervals of any interval over which they are true. Our preferred approach is to say that tenseless sentences such as, e.g. (30) really are true over tiny intervals, even ones in which nothing identifiable as writing can get done.

4.1 Specifying the reference interval

Consider the sentence:

(31) Angela has been working on the letter ever since 9:00.

Taking the underlying tenseless sentence here to be

(32) Angela be working on the letter[8]

the truth-conditions of (31) are plausibly given by

(33) $\forall J(J \subset [9{:}00, \text{TOU}] \rightarrow (\text{Angela be working on the letter})(J))$

where TOU is the *time of utterance*. Generalizing from (33) in the manner of section 2, we propose that *since* (or *ever since*) can express the temporal function

(34) $\forall J(J \subset [t, \text{TOU}] \rightarrow \phi(J))$

where t is the argument to the preposition. This temporal function is clearly of form (20) with reference interval $I = [t, \text{TOU}]$. As the reference interval here is bounded by TOU, we say that we have an *indexical* use of *since*.[9]

A change of tense causes the upper bound on the reference interval to be assigned not the TOU, but rather, the *reference time* (hereinafter, TOR) of the discourse in which the sentence occurs.[10] Thus, in

(35) Bill wandered into the office at 10 o'clock.
Angela had been working on the letter ever since 9 o'clock

the first sentence fixes the TOR to be 10:00, and the second sentence asserts that Angela was working on the letter throughout the interval [9:00, 10:00]—i.e. [9:00, TOR]. Here, it seems, *since t* has the temporal function

(36) $\forall J(J \subset [t, \text{TOR}] \rightarrow \phi(J))$

that is: form (20) with reference interval $I = [t, \text{TOR}]$. As the reference interval here is bounded by TOR, we say that we have an *anaphorical* use of *since*.

Thus, the upper bound of the reference interval for *since* is fixed either indexically or anaphorically. With *until*, it is the lower bound of the reference interval that is so fixed. Taking the indexical case first, we have

[8]Note that the underlying tenseless sentence contains a progressive aspect marker. The treatment of the progressive is discussed in the next section.

[9]The argument to *since*, which specifies one end of the reference interval, need not be a clock-time; it can also be the name of an event or time such as *nightfall* or *closing time*. We do not concern ourselves here with the ways in which times can thus be specified. In the sequel we shall assume that the arguments to prepositions somehow supply either a point in time or a duration in hours and minutes (as appropriate), both of which which we denote by t.

[10]The concept of reference time of a discourse is well-established in the literature, which we need not repeat here (see, for example, van Eynde [6]). Usually, the reference time is fixed as the time of the most recent completed event or action reported in the discourse.

(37) Angela will be working on the letter until 10 o'clock

the truth-conditions of which are plausibly given by

(38) $\forall J(J \subset [\text{TOU}, 10{:}00] \rightarrow (\text{Angela be working on the letter})(J))$.

Generalizing again, we propose that *until* can express the temporal function:

(39) $\forall J(J \subset[\text{TOU}, t]\rightarrow \phi(J))$

that is, form (20) with reference interval $I = [\text{TOU}, t]$. The anaphorical version of this temporal function (i.e, $I = [\text{TOR}, t]$) can again be produced by a tense shift. For example, in

(40) David came into the office at 9 o'clock and gave Angela a letter to type.
Angela was working on the letter until 10 o'clock

the first sentence fixes the TOR to be 9:00, and the second sentence asserts that Angela was working on the letter throughout the interval [9:00, 10:00]—i.e. [TOR, 10:00].

Thus, *since* and *until* differ with respect to which bound of the reference interval is fixed indexically or anaphorically. With *since*, the reference interval stretches backward from the TOU/TOR; with *until*, it stretches forward from the TOU/TOR. Accordingly, we shall say that *since* expresses a *backward-looking* temporal function, and *until* a *forward looking* temporal function.

So far we have encountered temporal functions in which one bound on the reference interval is given directly by the prepositional argument t. It is possible, however, to specify this bound as an offset relative to the TOU or TOR. Thus, the truth-conditions of (one reading of)

(41) Angela has been working on the letter for 1 hour

are plausibly given by

(42) $\forall J(J \subset[\text{TOU - 1hr, TOU}]\rightarrow (\text{Angela be working on the letter})(J))$

so that the temporal preposition *for* has a temporal function of form (20), but this time with reference interval [TOU - 1hr, TOU]. The same tense-change as for *since* results in anaphorical, as opposed to indexical usage—i.e in a reference interval [TOR - 1hr, TOR], thus:

(43) David came the office at 10 o'clock.
Angela had been working on the letter for 1 hour

since Angela is here (on one reading) asserted to have been working throughout the period [9:00, 10:00].

Thus, *since* and *for* differ with respect to the way their arguments fix one of the bounds on the reference interval. With *since*, the bound is specified directly; with *for* it is specified using an offset relative to the TOU/TOR. Accordingly, we shall say that *since* expresses an *absolute* temporal function, and *for* a *relative* temporal function.

In fact, if a non-perfective verb is used, *for* has a forward-looking temporal function. Thus, the sentence

(44) Angela will be working on the letter for 1 hour.

has truth-conditions:

(45) $\forall J(J \subset [\mathrm{TOU}, \mathrm{TOU} + 1\mathrm{hr}] \rightarrow$ (Angela be working on the letter)$(J))$.

This suggests that the preposition *for*, when used with a non-perfective verb, can have the temporal function

(46) $\forall J(J \subset [\mathrm{TOU}, \mathrm{TOU} + t] \rightarrow \phi(J))$

that is, form (20) with reference interval I= [TOU, TOU + t]. The anaphorical analogue (I = [TOR, TOR + t]) also exists:

(47) David came into the office at 9 o'clock and gave Angela a letter to type.
Angela was working on the letter for 1 hour.

We have seen how the prepositions *since*, *until* and *for*, when used with appropriate verb-tense and -aspect, can express temporal functions of form (20) with any of the eight reference intervals:

[t, TOU], [TOU-t, TOU], [t, TOR], [TOR-t, TOR],
[TOU, t], [TOU, TOU + t], [TOR, t], [TOR, TOR + t],

where t is the argument to the temporal preposition. These reference intervals can be identified by their position on three dimensions of variation: indexical/anaphorical, forward-looking/ backward-looking and absolute/relative. But what of temporal functions of the form (19)? In fact, it is straightforward to verify that the above eight reference intervals are also available here. In what follows, we consider only indexical temporal functions; the anaphorical cases are exactly analogous.

It is well-known that *since*-sentences are ambiguous between universal and existential uses (Mittwoch [13]). Thus,

(48) Angela has been working on the letter since 9:00

can be used to say that Angela has spent *all the time* since 9:00 working on the letter (universal use), or, more weakly, *some time* since 9:00 working on the letter (existential use). (Notice that in sentence (31), the word *ever* was included to force the former interpretation.) The truth-conditions for the existential interpretation of (48) are

(49) $\exists J(J \subset [9{:}00, \mathrm{TOU}]$ & (Angela be working on the letter)$(J))$

suggesting that *since* can express the temporal function

(50) $\exists J(J \subset [t, \mathrm{TOU}] \;\&\; \phi(J))$

In contrast to *since*, *until* is unambiguously universal. The existential analogue of *until* is *by*. Thus,

(51) Angela will work on the letter by 10:00

can have, as truth-conditions,

(52) $\exists J(J \subset [\text{TOU}, 10{:}00] \;\;\&\;\; (\text{Angela work on the letter})(J))$.

So that *by* here has the temporal function

(53) $\exists J(J \subset [\text{TOU}, t] \;\&\phi(J))$

The reader should compare (51)–(53) with (37)–(39).[11]

The temporal preposition *for*, when used with a time-duration as its argument, is unambiguously universal. There are existential analogues, but often of a roundabout nature. The nearest thing to an existential analogue of backward-looking *for* is the prepositional construction *within the last/past/previous*. The existential analogue of forward-looking *for* is *within the next/coming*, or simply *within*. For example, if the time of utterance is 10:00, then (48), intended in the *existential* sense, is equivalent to

(54) Angela has been working on the letter within the last/past hour

and if the TOU is 9:00, then (51) is equivalent to

(55) Angela will work on the letter within (the next) hour.[12]

In this section, then, we have identified a group of sixteen temporal functions of forms (19) and (20), differing along four dimensions of variation: indexical/anaphorical, forward-looking/backward-looking, absolute/relative and universal/existential. We shall call these temporal functions the *group-I* temporal functions. The group-I functions can be expressed by the temporal prepositions *since*, *until*, *for*, *by*, *within the last* and *within the next*, given suitable verb-tense and -aspect. The question that we must now settle is how, exactly, these six prepositions combine with tense and aspect to cover the sixteen expressible temporal functions. For ease of exposition, we look at the backward-looking temporal functions first. Readers wishing to skip these details may proceed to section 4.4, referring to tables 1 and 2 for a summary.

4.2 Tense and aspect: the backward-looking temporal functions

Turning first to the choice between perfective and non-perfective aspect, we note that, in standard British English, the perfective is required for all the backward-looking group-I temporal functions. Non-perfective forms either sound irregular, or have a quite different temporal function. In particular, *since*, which only ever has backward-looking functions, normally requires a perfective:[13]

[11] The change from the progressive to the nonprogressive aspect is due to a special feature of the usage of *by*, and will be explained later.

[12] In fact, a better analysis of phrases such as *within the last half hour* etc. is given in section 7.3, where, in this case, the preposition is taken to be *within* and the prepositional argument *the last half hour*. In the present section, we treat *within the last* as a preposition in its own right just so as to fill a gap that would otherwise be left unfilled. But nothing really hinges on the propriety of doing this.

[13] However, the simple past with *since* is admissible in American and in informal British English (see Quirk [14]), pp. 1015 ff.

(56) ($\star$) Angela was working on the letter since 10:00

(57) ($\star$) Bill will deliver the mail since 10:00

For, which has both forward- and backward-looking functions, generally relies on the perfective to pick out the latter: compare (43), where the reference interval stretches back from the TOR, to

(58) David came into the office at 10 o'clock and asked Angela to type a letter.

Angela was working on the letter for 1 hour

where it stretches forward from the TOR. Similarly, *within the last* and its variants can be used without the perfective, but not in the sense discussed here. To see what a difference the perfective makes, compare

(59) Charles decided to wait for 1 hour.

David had turned up in/within the last/past five minutes.

(60) Charles decided to wait for 1 hour.

David turned up within the last five minutes

Sentence 59 says that David had turned up sometime in the five minutes before Charles decided to wait (so presumably Charles was waiting for someone else, or was waiting in the wrong place.) Sentence 60, by contrast, says that David turned up in the last five minutes of the 1 hour. (We discuss this usage in a later section.) So only the former sentence expresses a group-I temporal function.

Thus, we may formulate the rule:

> All backward-looking group-I temporal functions require the verb in the perfective aspect.

Turning now to the matter of tense, we have seen, by comparing (31) with (35), and (41) with (43), that the present perfective is used for indexical functions, whilst the past perfective is used for anaphorical functions, when the discourse is couched in the past. When the discourse is couched in the future, backward-looking anaphorical functions require the future perfective:

(61) Angela will presumably get into the office at 9 o'clock.

Bill will have been working in the department (ever) since 7:30.

(62) Charles will arrive at work at 10 o'clock after seeing the dentist.

David will have left the building within the previous half hour.

Here we have one example with *since* and one with *within the last*, but the same holds true for all the backward-looking group-I functions. Thus, we may formulate the rule:

indexical/ anaphorical	absolute/ relative	reference interval	existential/ universal	preposition	tense	perfective aspect
indexical	absolute	$[t, TOU]$	universal existential	*since*	PRES	Y
indexical	relative	$[(TOU - t), TOU]$	universal existential	*for* *within*	PRES	Y
anaphorical	absolute	$[t, TOR]$	universal existential	*since*	PAST/FUT	Y
anaphorical	relative	$[(TOR - t), TOR]$	universal existential	*for* *within*	PAST/FUT	Y

Table 1: The backward-looking group-I temporal functions. Each function is determined by the reference interval and the quantifier-type (existential or universal). The reference interval has its upper bound fixed at the time of utterance (TOU) or the reference time (TOR), and its lower bound determined either absolutely, or by an offset relative to the upper bound. Here, t is the argument to the preposition phrase (either a time or a duration).

> *Indexical* backward-looking group-I temporal functions require the present tense; *anaphorical* backward-looking group-I temporal functions require the past or future tenses, according to the tense of the discourse in question.

Table 1 summarizes the expressive possibilities for the backward-looking group-I temporal functions—i.e. those with reference interval bounded above by *TOU* or *TOR*—giving the required preposition, tense and aspect (perfective or nonperfective) for each case. The following regularities for this group of prepositions can be noted. (i) The indexical/anaphorical distinction is made by tense. (ii) The universal-existential distinction is made by choice of preposition (or is left ambiguous). (iii) The relative-absolute distinction is made by the choice of preposition (and the nature of the prepositional arguments).

There are one or two alternative forms for the preposition-column in table 1—duplicates, that is, which do not essentially extend the expressive power of the prepositional system. For instance, *for* + perfective can usually be replaced by *for the last/past* + perfective:

(63) Angela has been working on the letter for (the last/past) hour

(64) Angela came into the office at about 9:00.
David had been working there for (the past) two hours.

Another alternative form is *during the last/past*, which tends to be used mainly for universal temporal functions, though an existential reading is perhaps just possible:

(65) Charles could not have spoken to David, because he has been in the library during the past two hours (*i.e:* for the past two hours).

(66) (?) Bill has posted the parcels during the past two hours (*i.e:* within the past two hours).

The preposition *during*, in these examples, could also be replaced by *over*. Finally, *within the last/past* can be contracted to *in the last/past*.

4.3 Tense and Aspect: the forward looking temporal functions

We now proceed with the task of explaining how temporal prepositions combine with tense and aspect to express the forward-looking group-I temporal functions.

Turning first to the choice between perfective and non-perfective aspect, we note that the forward-looking members of the group-I temporal functions often do not take the perfective aspect. This we have already seen in the case of *for*, where the perfective is decisive in favour of a backward-looking function. For the other temporal prepositions having forward-looking group-I functions, the rules governing the perfective are more complicated.

The perfective is not available for the preposition *until*, if it is to have the reference interval [TOU, *t*] or [TOR, *t*]. Compare:

(67) David came into the office at 9 o'clock and gave Angela a letter to type. Angela was working on the letter until 10 o'clock.

(68) David came into the office at 9 o'clock and gave Angela a letter to type. Angela had been working on the letter until 10 o'clock.

Discourse (68) sounds slightly funny. The reference to the letter in the second sentence suggests that it ought to be the one mentioned in the first sentence; but then the past perfective seems to suggest that Angela had already begun working on the letter before David came into the office.

Until can more comfortably be used with the perfective aspect when the reference time of the discourse is (or can be taken to be) later than the time supplied by the argument of the *until*. Thus,

(69) David came into the office at 10 o'clock and gave Angela a letter to type. Angela had been working on another letter until 9 o'clock

sounds fine. But notice that here, the reference interval for *until* cannot begin with TOR (and it certainly cannot begin with TOU). We might say that the reference interval in this case is [START, 10:00], where START indicates the beginning of the temporal universe of discourse. How this time is determined is not clear, but certainly, some contextual or pragmatic devices other than TOR and TOU must be at work here.

So, the *until* in the second sentence in (69) does not have a group-I temporal function, because the reference interval is not bounded by the TOU/TOR. The reader is invited to verify that analogous observations apply to the discourses couched in the future tense: the future perfective can be used with *until*, but the effect is that the reference interval begins neither with TOR nor TOU, but rather, at some possibly earlier point otherwise contextually or pragmatically determined.

With *by*, the perfective can play a similar role. Thus, as has been pointed out (Mittwoch [13]), one possible difference between the sentences

(70) Angela will type the letter by 10 o'clock

(71) Angela will have typed the letter by 10 o'clock

is that the latter, but not the former, leaves open the possibility that the letter has already been typed at the time of utterance. In other words, the reference interval of (70) is [TOU, 10:00], whereas that of (71) extends backwards indefinitely, as it might be: [START, 10:00].

On reflection, however, it is not so clear that the perfective with *by* always functions so as to push the start of the reference interval back. For if (70) and (71) really did have truth-conditions

(72) $\exists J(J \subset [\text{TOU}, 10{:}00]\ \&\ (\text{Angela type the letter})(J))$

(73) $\exists J(J \subset [\text{START}, 10{:}00]\ \&\ (\text{Angela type the letter})(J))$

respectively, where START < TOU, we would expect sentence (71), which is logically weaker *and* syntactically more complex than (70), not to be assertable if one knows that Angela has not yet begun the letter, on pain of violating the principle of informativeness. And we would likewise expect competent speakers of English to be able to exploit this alleged difference in truth conditions to make inferences about the state of knowledge of a speaker who asserts (71)—namely, that he is not in a position to assert (70). Yet this is not so. It is surely in order to use (71) even when one knows the typing has not yet begun. And it is surely too optimistic to claim that ordinary speakers of English, upon hearing (71), will infer some special reason for the speaker's failure to assert (70).

In fact, the use of the perfective with *by* can have quite a different function—namely to stress the fact that the action in question will be completed strictly by the time mentioned. This is especially clear when the argument to the *by* is not a clock-time, but a date. Thus, of

(74) Bill will post the parcel by 10th October

(75) Bill will have posted the parcel by 10th October

the former, but not the latter, allows that the parcel be posted on the date in question.

Furthermore, when the *by*-phrase is in first position, the non-perfective, though not incorrect, is stylistically inferior:

(76) By 10 o'clock, Angela will type the letter.

(77) By 10 o'clock, Angela will have typed the letter.[14]

So we should be reluctant to adopt a simple view of the function of the perfective with *by*. Whilst the perfective sometimes functions, as with *until*, so as to alter the lower bound of the reference interval, it does not always do so. It can, for example, function so as to stress that

[14] On the traditional, Reichenbachian view, the future perfective indicates an event or state occurring or holding after the time of utterance and before the reference time. In the present case, it is almost as if the preposed *by*-clause requires a perfective because it shifts the reference time beyond the event time *before* the main verb is encountered. (It is striking to compare the perfective and non-perfective versions with the *by*-phrase in first and last position.) But note that, if we accept this account of the choice of the perfective here, we must remember that the semantics of *by*-sentences must be given in terms of the *old* TOR, before it was moved on by the preposed *by*-clause. So the Reichenbachian rule for the perfective requires a different reference time from that required by the semantics.

the argument to the *by* places a strict bound on the reference interval, or it can respond to the fact that the prepositional phrase has been preposed. And in these cases, it seems appropriate to take the perfective to have no effect on the truth-conditions of the *by*-sentence.

So far, we have observed the effect of the perfective on indexical uses of *by*—i.e. where the reference interval would normally be bounded below by TOU. The effect on anaphorical uses is analogous, as we can see by switching to the past tense:

(78) David came into the office at 9 o'clock and gave Angela some papers and a letter to type.

By 10 o'clock, Angela had typed/worked on the letter.

is perfectly acceptable, even though Angela could not have begun before 9:00, and

(79) David came into the office at 9 o'clock and gave Angela some papers and a letter to type.

Angela had typed/worked on the letter by 10 o'clock

though (maybe) stylistically inferior, also passes muster.

As a further observation on the role of the perfective, we note in passing that it functions with forward-looking uses of *within* and *in* more or less as described above for *by*. In particular, when *in* and *within* are used without the phrases *the last* or *the next* which disambiguate between backward- and forward-looking uses, the prefective does not function so as to select the latter. Thus, the second sentence in

(80) David came into the office at 9 o'clock.

Within twenty minutes, Angela had typed three letters for him

has a reference interval [TOR, TOR + 20 mins], despite the perfective. In fact, *for* is the only preposition in this group for which the perfective selects between forward- and backward-looking uses.

Thus, the best we can say about the behaviour of the perfective for the forward-looking group-I functions is captured in the rule:

> Forward-looking universal group-I temporal functions require the verb in non-perfective aspect: the use of the perfective with *until* has the effect of shifting the start of the reference interval to some other contextually determined point; the use of the perfective with *for* expresses a backward-looking temporal function.
>
> Forward-looking existential group-I temporal functions allow the verb in either perfective or non-perfective aspect (with a preference for the former when the prepositional phrase is pre-posed): the perfective *can*, however, be used to shift the start of the reference interval to some other contextually determined point.

Having discussed the perfective aspect for the forward-looking group-I functions, we turn to tense. Whereas the backward-looking group-I functions use the present-tense for indexical fixing of the reference interval, the forward-looking uses prefer the future tense, and permit the present tense only for the universal cases, thus:

(81) Angela will be working on David's lecture notes for the next hour.

(82) Angela is working on David's lecture notes for the next hour.

(83) Bill will be sorting out Charles' parcels by noon.

The anaphorical forward-looking functions use the past or future tenses depending on the tense of the discourse, exactly as the anaphorical backward-looking uses:

(84) Angela came into the office at 9 o'clock

David gave her the letters to type by 10 o'clock

(85) Charles will come into the office at 9 o'clock

Bill will deliver the surprise present by 10 o'clock

Thus, we have the rule:

> *Indexical* forward-looking existential group-I temporal functions require the future tense; *Indexical* forward-looking universal group-I temporal functions require either the future tense or the present tense.
>
> *Anaphorical* forward-looking uses of temporal prepositions require the past or future tenses, according to the tense of the discourse in question.

The present perfective can (with some strain) be used with *until*, in the unlikely event that the TOU is equal to its argument. Thus, I can say, at 10:00

(86) Angela has worked on the letter until 10:00.

Similarly, the present perfective can be used with *by* if the TOU is before its argument. Thus, I can say, at 9:55

(87) Bill has posted the parcel by 10:00.

Again, however, the start of the reference period in both of these cases is neither the TOU nor any reference time; rather it is some other contextually determined point. So these uses of *by* and *until* do not have group-I functions.[15]

Table 2 summarizes the expressive possibilities for the forward-looking group-I temporal functions—i.e. those with reference interval bounded below by *TOU* or *TOR*—giving the required preposition, tense and aspect (perfective or nonperfective) for each case. Again, we mention in passing a number of variants. *For*, when its argument is a time point (rather than a duration), serves as a variant of *by*

[15]Similar remarks apply to (unusual) uses of the present progressive with *by* and *until* to report events in progress. It is also worth noting that the perfective can be used for emphasis in sentences such as (86) even after the reference period has elapsed. For example, if someone has a bet with you that Angela will not work on the letter until 10:00, you can use (86) after 10:00 to claim your money. In this paper, we ignore such uses of the perfective.

indexical/ anaphorical	absolute/ relative	reference interval	existential/ universal	preposition	tense	perfective aspect
indexical	absolute	$[TOU, t]$	universal existential	*until* *by*	FUT/(PRES) FUT	N Y/N
indexical	relative	$[TOU, (TOU + t)]$	universal existential	*for* *within*	FUT/(PRES) FUT	N Y/N
anaphorical	absolute	$[TOR, t]$	universal existential	*until* *by*	PAST/FUT PAST/FUT	N Y/N
anaphorical	relative	$[TOR, (TOR + t)]$	universal existential	*for* *within*	PAST/FUT PAST/FUT	N Y/N

Table 2: The forward-looking group-I temporal functions. Each function is determined by the reference interval and the quantifier-type (existential or universal). The reference interval has its lower bound fixed at the time of utterance (TOU) or the reference time (TOR), and its upper bound determined either absolutely, or by an offset relative to the upper bound. Here, t is the argument to the preposition phrase (either a time or a duration).

(88) Angela will have written the paper for 6 o'clock

In this case, then *for* expresses an existential temporal function.

In addition, *until* can often be replaced by *upto*, and *over* and *during* can serve as variants of *for* (in the universal sense considered above), though *during* can only with some strain be used existentially:

(89) Angela will work on the letter over/during the next half hour

or indeed of *within*

(90) Bill will post the letter over/during(?) the next half hour

Notice the characteristic ambiguity of *over* between universal and existential temporal functions. In addition, *within the next* can be contracted to *in the next*, and *within* to *in*, with the odd restriction that, in the latter case, the perfective aspect is required (otherwise, a completely different temporal function is signalled). Thus:

(91) Charles will send me email within the next five minutes

(92) Charles will send me email in the next five minutes

(93) Charles will have sent me email in the next five minutes

(94) Charles will have sent me email in five minutes

can all be used to say the same thing, namely, that Charles sends me email sometime in the interval [TOU, TOU + 5 mins] (but note that the above comments regarding the use of the perfective with *by* also apply here), yet

(95) Charles will send me email in five minutes

means something else (see section 6).

4.4 Combined rules for preposition, tense and aspect

The approach taken in this paper has been to analyse certain simple tensed sentences involving temporal prepositions by taking them to have the form

(96) F(ϕ)

where ϕ is a tenseless sentence and F a temporal function mapping ϕ onto a proposition. We have explained how temporal prepositions, verb-tense and -aspect and other factors can work together so as to pick out certain temporal functions—namely, those which we called the group-I temporal functions. Our results are summarized in brief in the tables we have presented above.

This approach is not entirely conventional. In particular, our decision to lump together temporal prepositions, tense and aspect as co-determinants of temporal function contrasts with the approach taken by many other writers, in which these components of language are analysed as sentence-operators with their own independent semantic rules.[16] On their approach, the sentence:

(97) Charles debugged the program between 9 o'clock and 10 o'clock

would be assigned the logical form

(98) PAST(BETWEEN(9:00, 10:00, Charles debug the program)

where PAST and BETWEEN are sentence-operators having the semantics looking something like:

(99) PAST(ϕ) is true (at a given time of utterance) if and only if there exists an interval J wholly earlier than the time of utterance such that ϕ is true over J

(100) BETWEEN(t_1, t_2, ϕ) is true over an interval J if and only if J is wholly contained in the interval $[t_1, t_2]$, and ϕ is true over J.

respectively. Similarly, the sentence

(101) Bill will have been posting the parcels between 9 o'clock and 10 o'clock

might be assigned a logical form something like

(102) FUT(PERF(PROG(BETWEEN(9:00, 10:00, Bill post the parcels)))

where FUT, PERF, and PROG are the operators corresponding to the future tense, and perfective and progressive aspects, respectively. They too, would be assigned semantics with a similar appearance to (99). (We need not concern ourselves with the details here.)

The key difference between this approach and that taken in this paper is that the latter makes no attempt to *separate out* the contributions of tense, aspect and temporal prepositions. Instead, we simply describe how these features *jointly* determine temporal function; for we believe that

[16] A good example of this sort of approach is the system of IQ semantics developed by Richards ([17])

this approach holds out the best prospect of a perspicuous overview of the expressive power which the temporal preposition system puts at our disposal. Our approach thus has more in common with the decision trees of Brée [1].

We remain agnostic about the possibility that our observations may one day be elegantly systematized in a collection of interacting, compositional, semantic rules of the form just sketched. And we readily accept that there are some features of the semantics of temporal prepositions that seem to cry out for an analysis in terms of scoping ambiguities between the prepositional operators and the aspectual operators. Whether a compositional analysis can elegantly systematize *all* the phenomena noted here, of course, is another matter; and that is what we are not so sure about. Ultimately, the success of the compositional approach must depend on how regular the interactions between tense, aspect and temporal prepositions in English are: a high degree of regularity, and the compositional approach accounts for a wide range of phenomena with a few simple rules; a low degree of regularity, with different groups of temporal prepositions interacting differently with tense and aspect, and the approach taken in this paper offers a clearer and simpler overview without a clutter of complicated rules and exceptions whose interactions are hard to work out. But there are so many approaches to the semantics of tense and aspect currently available that we can feel justified in our agnosticism.

5 The progressive aspect and aspectual class restrictions

In section 4, we saw how the temporal function associated with a preposition might depend on the tense (past, present or future) of the main verb, and on whether that verb had perfective or non-perfective aspect. No mention was made of the effect of progressive vs. non-progressive aspect. In this section, we discuss a number of issues concerning the interaction between the progressive aspect and the temporal prepositions.

5.1 The progressive aspect

The progressive aspect has two primary functions, both of them widely discussed in the literature. The first is to remove the implication that a event or action will be completed, where such an implication exists. Thus, of the sentences:

(103) Charles wrote the program

(104) Charles was writing the program

the former implies the latter, but not vice versa, since Charles might have started writing the program without finishing it. On the other hand, the sentences:

(105) Charles worked on the program

(106) Charles was working on the program

have identical truth-conditions.[17]

The second function of the progressive aspect concerns temporal anaphora. Whereas sentences denoting completed events (in the non-progressive) are generally taken to follow one after the other in a discourse, putting the verbs denoting those events into the progressive aspect makes those events overlap. Consider:

(107) David came into the office and sat down.

Angela typed a letter for him.

(108) David came into the office and sat down.

Angela was typing a letter for him.

In the first discourse, Angela starts to type the letter after David comes in and sits down. In the second discourse, she starts before David comes in and sits down. (But see Hinrichs [8] pp.54–56 for a discussion of some alleged exceptions.) These phenomena have been widely discussed, particularly with a view to giving compositional rules for the semantics of the progressive aspect as discussed in section 4.4 (see Lascarides [11], Parsons [15], Dowty [5], Hinrichs [8].) What concerns us in this and the following sections is the interaction between the progressive aspect and temporal prepositions.

5.2 The functions of the progressive aspect and temporal prepositions

In section 2, we distinguished between two types of tenseless sentences: completion sentences and non-completion sentences. Since one of the functions of the progressive is to remove the implication that an action is completed, where such an implication exists, we might ask whether tenseless sentences in the progressive-aspect fall into the non-completion category, according to our definition. In fact, this turns out to be the case.

Suppose, as before, that Angela writes a certain letter, starting at, say, 9:15, and finishing at, say 9:45. Then the sentence

(109) Angela was writing the letter between 9:20 and 9:40

will be be true, as will any other such sentence with a reference interval falling between 9:15 and 9:45. Following our discussion in section 2, it seems sensible to take the underlying tenseless sentence

(110) Angela be writing the letter

to be a non-completion sentence: if it is true over an interval I, then it is true over all subintervals of I. And this reasoning would seem to apply to all progressive-aspect sentences. In other words, atomic progressive aspect tenseless sentences are indeed non-completion sentences. (Note that the remarks concerning gaps in activities, as discussed in section 3, apply to progressive-aspect sentences as for non-completion sentences generally.)

[17] Lascarides [11] has actually claimed a technical difference in the truth conditions of (105) and (106), but not one that could be discerned in practice. Since this alleged difference is theory- rather than data-driven, I shall disregard it in what follows.

We remain non-committal in this paper as to the general semantics for the progressive aspect, of which there are a number to choose from. For our purposes, we merely claim that atomic tenseless sentences having the progressive aspect are non-completion sentences. In fact, this claim is a consequence of most treatments of the progressive in the literature.[18]

One other decision we make regarding sentences in the progressive aspect. In section 4, we took the sentence (31), which has perfective and progressive aspect, to have the underlying tenseless sentence (32), which contains a progressive marker, but no perfective marker. In fact, we have in general left in progressive markers, but not perfective markers, when extracting underlying tenseless sentences. We shall continue to do this merely because it provides us with a way of remaining agnostic on the question of the relationship between progressive and non-progressive forms of a sentence. As we shall see below, however, the temporal function expressed by a preposition can depend on whether the main verb has progressive or non-progressive aspect.

It is crucial to note that the tendency of the progressive to make events in a discourse overlap does not in general apply in the presence of certain temporal prepositions. In

(111) David came into the office and gave Angela a pile of work

Angela was writing the letters of invitation until 12 o'clock

what is actually asserted is that Angela was doing the writing from the TOR until 12:00. Indeed, it is natural to suppose that the letters Angela was writing formed part of the work which David gave her, so that she could not have started before the TOR. The reader should compare discourses (108) and (111). Exactly analogous remarks apply to *by*:

(112) David came into the office and gave Angela a pile of work

She was writing the letters of invitation by 12 o'clock.

Clearly, the writing of the letters of invitation is not supposed to overlap the TOR set up by the previous sentence. Thus, the truth-conditions given in section 4 for *until* and *by* stand, despite the oft-noted phenomenon, illustrated in (108), that the progressive aspect forces us to interpret events as overlapping. Where temporal prepositions are involved, the progressive does not always force us to interpret events as overlapping in time.[19]

5.3 The progressive and the existential/universal ambiguity

Where a temporal preposition is ambiguous between universal and existential uses, e.g. *since*, the progressive aspect tends to favour, but not necessitate, a universal interpretation, whilst the non-progressive aspect (even for non-completion sentences) favours an existential interpretation. For example, of the sentences

[18] For example, Dowty, in his (simplified) account (Dowty [5]) suggests that PROG(ϕ) is true over an interval J if ϕ is true over some interval I such that $J \subset I$. This immediately implies that ϕ is a non-completion sentence in our sense.

[19] Could it be that the temporal preposition shifts the time of reference on, as it were, *before* the progressive aspect is taken into account? Possibly so. But then we would have to introduce two reference times: the *old* TOR which is the start of the reference interval (needed to specify the reference-interval of the temporal function), and the *new* TOR, which the event of action in question is supposed to overlap.

(113) David has worked on the paper since 9 o'clock

(114) David has been working on the paper since 9 o'clock

the former is more likely to be used to say that David has been working on the paper some of the time since 9:00, and the latter more likely to be used to say that he has been doing so the whole time since 9:00. But both readings are available for both sentences.

There is a rather quirky interaction between the progressive aspect and *by*. Consider the sentences:

(115) David will work on the paper by 10 o'clock

(116) David will be working on the paper by 10 o'clock

At first glance, the difference between these sentences seems to be this: the second, but not the first, suggests that David will *still* be working on the paper at 10:00. So it looks like the progressive is having some odd effect on the truth-conditions of *by*-sentences.

On second thoughts, however, to build the above-mentioned suggestion into the *truth-conditions* of (116) would be a mistake. If it turns out that David works on the paper from 9:20 to 9:40, do we really want to say that (116), if uttered at 9:00, is *false*? (If you had had a bet on (116) in those circumstances, would you really have lost?). And do we really want to say that

(117) David will not be working on the paper by 10 o'clock

would then have been true? We suggest not. Rather, any hint in (116) that David is still working on the paper at 10:00 is to be accounted for as a (conventional) implicature, rather than as part of the sentence's truth-conditions. Thus, we take (116) and (115) to have the same truth-conditions.

5.4 The progressive and aspectual class restrictions

We now come to the issue of aspectual class restrictions on the use of temporal prepositions. As has often been noted (e.g. Herweg [7]), sentences involving a completion-sentence together with a temporal preposition which has only universal temporal functions (such as *from ...until*) can sound odd:

(118) Angela wrote the letter from 9 o'clock until 10 o'clock

(119) Bill ran to the bank from 9 o'clock until 10 o'clock

Sentence (118) is most naturally interpreted as saying that Angela spent the interval [9:00, 10:00] engaged in writing the letter, without necessarily finishing. That is, the suggestion of (118) is that she stopped writing when 10:00 came round, not when the letter was completed. Sentence (119) is most naturally interpreted as saying that Bill ran to the bank *repeatedly* between the said times. That is, the suggestion of (119) is that Bill stopped running when 10 o'clock came round, not when he reached the bank.

These examples both involve the preposition *from …until*, which, as we have seen, only has universal uses. When a preposition has both universal and existential uses, however, the use of a completion verb can help decide in favour of the latter. Thus

(120) The bomb has exploded since 9 o'clock.

naturally takes an existential reading.

Thus, temporal prepositions with universal uses do not 'like' completion sentences. When universal temporal prepositions are used with what would normally be completion sentences, those sentences are re-interpreted as non-completion sentences by adopting either an action-in-progress interpretation as with (118), or a repetition interpretation as with (119)—whichever makes more sense.

The difficulty of using completion-sentences with universal temporal functions is quite natural given the semantics proposed above, since the resulting tensed sentences would all be false. Universal temporal functions assert that the underlying tenseless sentence is true over all subintervals of the reference interval; and this condition can by definition never be satisfied with completion-sentences.

If, as we are suggesting, tenseless sentences having the progressive aspect are non-completion sentences, then they can be used freely with universal temporal functions. In this case, the interpretation can still either be that of an action in progress or of a repeated action, whichever makes more sense. Thus, whilst

(121) Angela was writing the letter from 9 o'clock until 10 o'clock

clearly has an action-in-progress interpretation, the sentence:

(122) David was kicking the photocopier from 9 o'clock until 10 o'clock

clearly has a repeated-action interpretation. As for:

(123) Bill was running to the bank from 9 o'clock until 10 o'clock

it depends on how far away the bank is.

Thus, we stand by our claim, implicit in the absence of any mention of the progressive in section 4, that, aside from a weak tendency to favour universal interpretations, the progressive aspect does not affect the temporal function expressed by the temporal prepositions we have considered so far. True, unambiguously universal temporal prepositions such as *from …until*, *until* and *for* are immiscible with some non-progressive tenseless sentences, but that just seems to be a matter of our linguistic intuitions' not allowing us to say something obviously false. To see the progressive interacting more strongly with temporal prepositions, we must look at another group of temporal functions: the *group-II* functions, which are considered in the next section.

6 The Group-II temporal functions

In this section, we shall see how various temporal prepositions can be used to express temporal functions of the by now familiar forms

(19) $\exists J(J \subset I \& \phi(J))$

(20) $\forall J(J \subset I \rightarrow \phi(J))$

but where the reference interval I is of negligible temporal extension. These temporal functions are thus used to *locate* events and states in time rather than to report on their duration.

6.1 Specifying the reference interval

When used with non-progressive verbs, the preposition *at* functions so as to assert that some event or state occurs or holds within a relatively small interval located near to the time specified by the prepositional argument. Thus, consider:

(124) Angela will write the letter at 10 o'clock.

Suppose Angela does write the letter, starting at time t_1 and finishing at t_2. Then (124), on any reasonable interpretation, must be taken to say that the whole of the interval $[t_1, t_2]$ is near to 10:00. Thus, if t_1 = 7:30, (124) is false—no matter how close to 10:00 Angela finished. And (124) is of course likewise false if t_2 lies too long after 10:00. It follows that there is a limit to how long the time period $[t_1, t_2]$—and hence the letter Angela wrote in it—can be: *even Angela* couldn't have written a 50-page letter at 10:00.[20]

It also follows that the truth-conditions for (124) are inherently vague. To insist otherwise—to insist, that is, that (124) is only true in case Angela wrote the letter at *exactly* 10:00—would simply be to insist that (124) and almost all other sentences like it are false.

Accordingly, we propose to give the truth-conditions of (124) as

(125) $\exists J(J \subset [10{:}00 - \varepsilon, 10{:}00 + \varepsilon]$ & (Angela write the letter)$(J))$

where ε is some contextually determined duration. Generalizing, as usual, we propose that *at* can express the temporal function:

(126) $\exists J(J \subset [t - \varepsilon, t + \varepsilon] \;\&\; \phi(J))$

that is, form (19) with reference interval $[t - \varepsilon, t + \varepsilon]$. The vagueness inherent in such sentences is pushed into the determination of ε, leaving a relatively clean semantics for the temporal preposition. Notice that (125) does not require that Angela be in the middle of writing the letter at 10:00—she could finish just before or start just afterwards. This is in accordance with intuition.

When used with verbs in the progressive aspect, by contrast, *at* functions so as to assert that some event or state occurs or holds over some interval which includes the time specified by the prepositional argument. Thus, consider:

[20] Admittedly, we can say things like: "The QE II will sail to New York at 3 o'clock'. But we can probably best take this to be simply elliptical for the more correct: "The QE II will set sail for New York at 3 o'clock'.

(127) Angela will be writing the letter at 10 o'clock.

Sentence (127) can be true even if Angela started writing the letter some time before 10:00, and even if she does not finish until some time after; that is why there is no problem about saying that Angela *was typing* a 50-page letter at 3 o'clock. Moreover, *at*-sentences in the progressive can, in some sense, be *exactly* true. It is, for instance, possible to say:

(128) The shot was fired at exactly 10 o'clock, the sound of the gun being drowned out by the first chime of the clock. Angela was nearby, but was working on the letter at 10 o'clock, so could not have been the murdress.

And examples requiring arbitrarily fine timing are simple to construct.[21] Replacing the critical progressive by a non-progressive results in a sensible train of reasoning only if Angela's typewriter was sufficiently far from the scene of the shooting to make the requisite journey impossible:

(129) The shot was fired at exactly 10 o'clock, the sound of the gun being drowned out by the first chime of the clock. Angela was nearby, but worked on the letter at 10 o'clock, so could not have been the murdress.

When the logical function of an *at* sentence is to block out a small segment of time, the progressive is required.

By analogy with the semantics proposed in the last section for the group-I temporal functions, we propose to give the truth-conditions of (127) as

(130) $\forall J(J \subset [10{:}00 - \varepsilon, 10{:}00 + \varepsilon] \rightarrow (\text{Angela be writing the letter})(J))$.

Recalling the observation of section 5 that tenseless sentences having progressive aspect are always non-completion sentences, (130) is simply the condition that Angela have been engaged in the writing over some interval including 10:00.

It was claimed in section 5 that, where prepositions having group-I temporal functions are concerned, the progressive favours universal readings, whereas the non-progressive favours existential readings. It seems that we have a similar phenomenon here, except that the difference is much more striking.

Thus, *at*, when used with a verb having progressive aspect, can express the temporal function

(131) $\forall J(J \subset [t - \varepsilon, t + \varepsilon] \rightarrow \phi(J))$.

that is, form (20) with reference interval $[t - \varepsilon, t + \varepsilon]$. We see, then, from sentences (124) and (127), that *at* can have an existential or universal function, depending on whether the main verb has non-progressive or progressive aspect. The reference interval, however, depends only on the argument to *at* (and on whatever contextual parameters determine ε).

At specifies the centre of its reference interval *absolutely*, but the same job can also be done using an offset. The sentences:

[21]Note that sentences such as (127) are infected by the vagueness arising from breaks in activities and states (see the discussion in section 3).

(132) Angela will write the letter in an hour/in an hour's time/(in) an hour from now

have, as plausible truth-conditions:

(133) $\exists J[J \subset[\mathrm{TOU} + 1\text{ hr} - \varepsilon, \mathrm{TOU} + 1\text{ hr} + \varepsilon]$ & (Angela write the letter)(J)).

By reasoning parallelling the above discussion of *at*, we propose that the sentences

(134) Angela will be writing the letter in an hour/in an hour's time/(in) an hour from now

have truth conditions

(135) $\forall J[J \subset[\mathrm{TOU} + 1\text{ hr} - \varepsilon, \mathrm{TOU} + 1\text{ hr} + \varepsilon] \rightarrow$ (Angela be writing the letter)(J)).

So it looks as if *in* (and the alternative forms suggested above) can express an existential or universal temporal function with reference interval $[\mathrm{TOU} + t - \varepsilon, \mathrm{TOU} + t + \varepsilon]$.

Sentence (132) specified the reference interval relative to the TOU. But, of course, an analogous function exists for the TOR:

(136) At 9:00 Charles went into his office.

David telephoned him after an hour.

Here, the first sentence fixes the TOR at 9:00 and the reference interval for the second sentence is $[\mathrm{TOR} + 1\text{ hr} - \varepsilon, \mathrm{TOR} + 1\text{ hr} + \varepsilon]$. Notice the change of temporal preposition from *in* to *after*: the forms *in an hour*, *in an hour's time* are not normally used anaphorically, and *after an hour* is not normally used indexically.

Recall from section 4 the distinction between forward-looking temporal functions on the one hand, where an offset is added to the TOU/TOR, and backward-looking temporal functions on the other, where the offset is subtracted. The same distinction applies in the present case. Consider:

(137) Angela wrote the letter an hour ago.

Plausible truth-conditions here are:

(138) $\exists J(J \subset[\mathrm{TOU} - 1\text{ hr} - \varepsilon, \mathrm{TOU} - 1\text{ hr} + \varepsilon]$& (Angela write the letter)(J))

so that the reference interval is $[\mathrm{TOU} - 1\text{ hr} - \varepsilon, \mathrm{TOU} - 1\text{ hr} + \varepsilon]$.

The anaphorical analogue (i.e. with TOR replacing TOU) can be obtained by changing the verb to the perfective aspect:

(139) At 9:00 Charles went into his office

Bill had placed a parcel on his desk an hour ago

or (much better) by using the preposition *before*,[22] again with a perfective:

[22]*Before*, when used in this way, is normally taken to be an adverb rather than a preposition. However, as we can see, like *ago*, it fits neatly into the temporal preposition system. Other words normally classified as adjectives, such as *later*, *earlier*, *previously* may be used in place of *before* and *after*.

(140) At 9:00 Charles went into his office

Bill had placed a parcel on his desk an hour before.

The reference interval of the second sentence in these cases is [TOR - 1 hr -ε, TOR - 1 hr + ε]. In fact, in anaphorical uses, there is a strong preference for *before* over *ago*.

In this section, then, we have identified a group of ten temporal functions of forms (19) and (20), differing along two dimensions of variation: absolute/relative and universal/existential; the relative functions vary along two additional dimensions: indexical/anaphorical and forward-looking/backward-looking. We shall call these temporal functions the *group-II* temporal functions. The group-II functions can be expressed by the temporal prepositions *at*, *in*, *ago*, *after* and *before*, given suitable verb-tense and -aspect. The question that we must now settle is how, exactly, these five prepositions combine with tense and aspect to cover the ten expressible temporal functions.

6.2 Choice of tense and aspect

We have just seen that, when it comes to the group-II temporal functions, the progressive aspect is typically used to express the universal members of that group, whereas the non-progressive is used to express existential members of that group. Certainly, the texts (128) and (129) show that it can be difficult to interpret sentences with non-progressive aspect as involving universal group-II temporal functions. But is it possible to interpret sentences with progressive aspect as involving existential temporal functions? That is, can we see a sentence like (127) as having, as truth-conditions, not (130), but

(141) $\exists J(J \subset [10{:}00 - \varepsilon, 10{:}00 + \varepsilon] \&$ (Angela be writing the letter)$(J))$?

What makes this question hard to decide is that often, when we give times for events, we often do so only approximately. And this obliterates the distinction between the universal and existential readings. So the matter is rather unclear. Perhaps we should simply say:

> Group-II universal temporal functions require the verb in the progressive aspect; group-II existential temporal functions favour the verb in the non-progressive aspect.

In section 8, we will encounter a reason to prefer this cautious formulation.

The selection of tense is straightforward. Firstly, the tense of *at* can simply reflect the relationship between its argument and the TOU, with present tense examples tending to be interpreted as denoting future events. Thus, if the time is now 9:30, I might say:

(142) Bill arrives/will arrive at 10 o'clock

(143) Charles arrived at 9 o'clock.

Alternatively, if the *at*-sentence occurs in a discourse which is not related to the TOU—such discourses are standardly in the past tense—then the tense of the *at*-sentence is simply the tense of the discourse.

For the relative group-II temporal functions, which use the prepositions *in*, *after*, *ago*, *before*, the situation is similar (but not identical) to that for the group-I relative temporal functions. Anaphorical cases take the tense of the discourse, thus:

(144) Angela got into the office at 9 o'clock.
David arrived after an hour.

(145) Angela will get into the office at 10 o'clock.
David will have left a message on the board half an hour before.

And indexical uses take the past tense for backward-looking cases and the future or present for forward-looking cases:

(146) Bill arrives/will arrive in 30 minutes

(147) Charles arrived 30 minutes ago.

The choice of perfective or non-perfective aspect with group-II temporal functions hinges on other factors. With *at*, the perfective is used when its argument is before the reference time in a discourse, when there is a reference time available:

(148) Angela came into the office at 9 o'clock
David had arrived at half past 8.

(149) Charles will get into work at 8 o'clock
Bill will have placed the parcel containing the present there at half past 8.

However, *at* can be used with the future perfective to mean the same as *by*. Thus, in (149), the natural reading has it that Bill will deliver the present at or about 8:30. But it might be possible to utter the same sentence to mean that Bill will deliver the present *at any time before* 8:30. This is a bit clearer if the *at*-phrase is in first position:

(150) At half past 8, Bill will have delivered the parcel containing the present

On this reading, then, *at* has the force of *by*, as discussed in section 4.[23] Thus, it does not have a group-II temporal function.

When *in* has a group-II function, the perfective is unavailable, because it selects one or other of the senses of *in* which are equivalent to *within*. Thus,

(151) Angela will have typed the letter in an hour

[23]It is surely natural to account for this ambiguity in terms of scoping, the idea being that the group-II reading gives the perfective scope over the *at*, whereas the group-I reading (on which *at* could be replaced by *by*) gives the *at* scope over the perfective. And observations such as this certainly militate in favour of a compositional approach based on rules such as (99) and (100). But, the issue of whether such rules really provide the best *overall* explanation of temporal prepositional usage in English—however tempting they may be for certain cases—is one about which we remain agnostic here.

cannot mean that she will type it within some small time interval around one hour from now.

With *ago*, the perfective distinguishes the anaphorical from the indexical use. Thus:

(152) Angela arrived an hour ago (*i.e. an hour before now*)

(153) Bill saw Angela whilst walking past her office.

She had arrived an hour before/ago. (*i.e. an hour before then*)

Finally, when *after* and *before* have group-II temporal functions, as discussed here, *after* prefers the non-perfective and *before* the perfective:

(154) Bill will put the parcel on Charles' desk at 9 o'clock

The present will have been wrapped up an hour before

(155) Bill will put the parcel on Charles' desk at 9 o'clock

Charles will arrive after 30 minutes.

But similar remarks apply regarding the use of the perfective as for *at*.

Thus, the behaviour of perfective in regard to group-II temporal functions appears, on the face of it, somewhat erratic. Of course, this appearance may be an artifact of the manner in which we have chosen to present the data. Perhaps, for example, we can rely here on the Reichenbachian principle, that the perfective characterizes situations in which the event-time comes before the reference time (see Hornstein [9] ch. 1). Or perhaps compositional rules such as (99) and (100), together with similar rules for the perfective aspect, can be framed so as to yield the truth-conditions as we have set them out here. But we have already declared that it is not our aim here to separate out the contributions of tense, aspect and temporal prepositions to the temporal function involved in a given tensed sentence. Of course, it would be nice if such a theory were to hand. Until then, however, the observations of this section are summarized in table 3.

7 Other temporal functions

In this section, we briefly distinguish three more groups of temporal functions, all of forms (19) or (20). Their structure is less interesting than that of groups I and II, and only a brief outline is given here for the sake of completeness.

7.1 The group-III temporal functions

Under this group we understand existential and universal temporal functions with reference intervals [START, t] or [t, END], where t is the time supplied by the prepositional argument and START and END are contextually supplied parameters indicating the start- and end-times of the temporal universe of discourse. That is, the group-III temporal functions are:

(156) $\exists J(J \subset [\text{START}, t] \ \& \ \phi(J))$

The absolute group-II functions:

reference interval	existential/ universal	preposition	tense	perfective aspect	progressive aspect
$[(t-\varepsilon, t+\varepsilon)]$	universal	*at*	PAST/PRES/FUT	Y/N	Y
	existential	*at*	PAST/PRES/FUT	Y/N	N

The relative group-II functions:

forward/ backward	indexical/ anaphorical	reference interval	existential/ universal	prepos- ition	tense	per- fective	pro- gressive
forward	indexical	[(TOU+t-ε, TOU+t+ε)]	universal existential	*in*	FUT/ (PRES)	N	Y N
forward	anaphorical	[(TOR+t-ε, TOR+t+ε)]	universal existential	*after*	PAST/ FUT	N	Y N
backward	indexical	[(TOU-t-ε, TOU-t+ε)]	universal existential	*ago*	PAST	N	Y N
backward	anaphorical	[(TOR-t-ε, TOR-t+ε)]	universal existential	*before/* *ago*	PAST/ FUT	Y	Y N

Table 3: The group-II temporal functions. Each function is determined by the reference interval and the quantifier-type (existential or universal). The reference interval centres around a point which is given either absolutely or relatively. In the latter case, the function may be determined relative to the TOU (indexical) or the TOR (anaphorical), and may be fixed by adding (forward-looking) or subtracting (backward-looking) the offset. Here, t is the argument to the preposition phrase (either a time or a duration).

(157) $\forall J(J \subset [\text{START}, t] \ \rightarrow \ \phi(J))$

(158) $\exists J(J \subset [t, \text{END}] \ \& \ \phi(J))$

(159) $\forall J(J \subset [t, \text{END}] \ \rightarrow \ \phi(J))$.

We have already met certain uses of *until*, *by* and *at* with the perfective aspect, in which we took the reference interval to be [START, t]. However, the main prepositions expressing the group-III temporal functions are *before* and *after*. Thus:

(160) David wrote the letter before 10 o'clock

(161) Charles will debug the program after 10 o'clock

obviously locate the reported events as having occurred sometime within [START, 10:00], and [10:00, END] respectively.

In such cases, existential readings are preferable, but universal readings are also available in which case there is a strong preference the progressive, as with group-II functions. Thus, in:

(162) Charles will have no time at all this morning. He has a lecture at the moment,
and he will be debugging the program after 10 o'clock

the last clause is intended to imply that Charles will be engaged throughout an interval beginning at 10 o'clock and ending at END, the end of the temporal domain of discourse. In this paper, we dodge the issue of which factors determine START and END.

The prepositions *upto* and *from* can also, it seems, have universal group-III temporal functions:

(163) Angela had worked on the letter upto 10:00

(164) David worked on his lecture notes from 9:00 (on(wards))

7.2 The group-IV temporal functions

This group contains just two temporal functions of the general forms (19) and (20), where the reference interval I is given directly by a pair of arguments to the prepositions. That is, the group-IV temporal functions are:

(165) $\exists J(J \subset [t_1, t_2] \ \& \ \phi(J))$.

(166) $\forall J(J \subset [t_1, t_2] \ \rightarrow \ \phi(J))$.

We have already met prepositions expressing these temporal functions: *between…and* and *from…until*, since they were used in section 2 to introduce the general approach taken here. Recapitulating briefly, *from…until* always has the temporal function (166), whereas *between…and* can have both temporal functions. Thus

(167) Angela was writing the letter from 9:00 to 10:00

is unambiguously universal: Angela spent the whole time between the said times writing the letter. However,

(168) Angela was writing the letter between 9:00 and 10:00

whilst certainly having an existential reading—Angela spent some time between the said times writing the letter—can also arguably be taken, in certain contexts, as asserting the same as (167). Consider the following mini-text:

(169) Angela was writing the letter (in the office) between 9 o'clock and 10 o'clock. But the victim was stabbed in the lift at about a quarter past nine, which eliminates Angela as a suspect.

For this text to make sense, the first sentence must be taken to assert that Angela was writing the letter *throughout* the period in question, that is, as having the temporal function (166). If so, then, we should allow that *between…and* can serve to quantify either existentially, or universally—that is: it is ambiguous between an existential and a universal temporal function.

Notice that, in claiming ambiguity here, we are relying crucially on the fact that the speaker of the above mini-text did not merely *leave open the possibility* that Angela wrote throughout the period in question: rather, he *intended to be taken as asserting* that she did. (Otherwise, the argument that she did not commit the murder would not be cogent.) And this intention could not be achieved if *between…and* only had the existential reading. So we really do need to treat *between…and* as ambiguous.

7.3 The group-V temporal functions

This group also contains just two temporal functions of the form (19) and (20), where the reference interval I is given directly as the argument to the preposition. That is, the group-V temporal functions are:

(170) $\exists J(J \subset i \;\&\; \phi(J))$.

(171) $\forall J(J \subset i \;\rightarrow\; \phi(J))$.

where i is a variable ranging over time intervals.

The temporal prepositions *through*, *throughout* and *within* can be used to express group-V temporal functions, where *through* and *throughout* always express a universal function and *within* always expresses an existential function:[24]

(172) Bill was in the porter's lodge throughout the period from 9 o'clock to 10 o'clock

(173) Charles slept through the meeting

[24]The difference between *through* and *throughout* is discussed in Brée *et al.* [3].

(174) Angela received the message within that period.[25]

Of course, there are many special words for intervals of particular interest, and these can be used as arguments to temporal prepositions. For example, we can quantify universally over subintervals of a named interval, thus:

(175) David worked on the the paper throughout Monday/the weekend/May.

Some temporal prepositions, in particular *over* and *during*, can be used either existentially or universally:

(176) Charles worked on the program during (*but not:* over) the week

(177) Charles worked on the program over/during the weekend

where, as we see, there are some restrictions on the choice of preposition stemming from the prepositional object. Yet other prepositions signal unambiguously existential quantification:

(178) Angela worked on the letter on Monday

(179) Angela worked on the letter at the weekend

(180) Angela worked on the letter in May

where, in this case, the choice of preposition is usually heavily dependent on the prepositional object. In this paper, we shall not concern ourselves with restrictions on prepositional usage stemming from the type of prepositional object used.

The choice of tense and perfective or non-perfective aspect play no interesting role in determining the temporal function in these cases. Accordingly, rules governing this choice will not be discussed here.

7.4 *Over:* another form of temporal function?

The temporal preposition *over* can as we have just seen, function so as to quantify universally or existentially over a named time interval. But it may have another temporal function as well. Consider the sentence:

(181) Angela wrote the letter over the last half hour/ the period from 9:15 to 9:45/etc.

Unlike *from…until*, which tends to sound odd with completion sentences, the use of *over* in (181) sounds much better. And, unlike *within*, which expresses an existential temporal function, the use of *over* here suggests that Angela really did take the whole period: at 9:15 she began, and at 9:45 she finished. If these observations are correct, then the *over* should be taken to express the temporal function

[25]In section 4, we listed *within the last* as a group-I preposition, taking a duration as argument. In fact, however, it is surely better to analyse prepositional phrases such as *within the last five minutes* as consisting of a noun-phrase *the last five minutes* which picks out an interval, and the group-V existential preposition *within* which expects an interval as argument. Similar remarks apply to the constructions *for the next…*, *during the last…* etc.

(182) (Angela write the letter)(i)

where the variable i ranges over time intervals, and is supplied by the prepositional argument. Clearly, the temporal function (182) is not of the forms (19) or (20). Corresponding observations perhaps apply to the compound preposition *from…to*, which also perhaps sounds better than *from…until* with completion sentences:

(183) Angela wrote the letter from 9:15 to 9:45

It is important to note that, in both (181) and (183), the implication that the letter was completed (at 9:45) is supposed to be preserved (so that we really have a completion-sentence as the underlying tenseless sentence).

On the other hand, it is probably possible to maintain that, for example, sentence (181) does not really *imply* that the letter was begun at 9:15 and finished at 9:45 (though it may conventionally implicate these things). For our linguistic intuitions may be unclear on this point. It may be unclear, that is, that there is a sense of (181) which implies that Angela finished the letter, and which is *false* if she started at 9:20 and finished at 9:40. So it is not clear whether we should really recognize another type of temporal function expressible with prepositions such as *over* and *from…to*. We leave this question open.

8 The floating temporal functions

Leaving aside the doubtful case of section 7.4, we have so far considered temporal functions belonging to one of two categories: the existential functions, which allow one to say that something is true over some subinterval J of a given reference-interval I, and the universal functions, which allow one to say that something is true over all subintervals J of a given reference-interval I. We now turn to a group of temporal functions which are neither existential nor universal: the *floating* functions. Prepositions expressing functions in this group include *for*, *within*, *in* and *over*.

The floating functions themselves fall into two categories. We begin with an oft-noted ambiguity in *for*-sentences. The sentence

(184) Angela was working on the letter for 1 hour

can be used, as in discourse (58), to say that Angela was working throughout the interval stretching forward 1 hour from the TOR. In that case, we give (184) truth-conditions:

(185) $\forall J(J \subset [TOR, TOR + 1hr] \rightarrow$(Angela be working on the letter)(J)).

But (184) can also be used to say that Angela spent a period of 1 hour sometime in the past working on the letter. In which case, plausible truth-conditions would be, by analogy with (185),

(186) $\exists J(J \subset [START, TOU]$ & $dur(J) = 1\ hr$ & $\forall K(K \subset J \rightarrow$ (Angela be working on the letter)(K)))

where dur(J) is a function that returns the duration of interval J. Thus, *for*, on this reading, has a temporal function of the form:

(187) $\exists J(J \subset I \;\; \& \;\; dur(J) = t \;\; \& \;\; \forall K(K \subset J \rightarrow \phi(K)))$

where I is, in this case, the interval [START, TOU]. It is as if the reference interval in form (20) has been allowed to float.[26] So we might say that temporal functions having form (187) are *floating universal* functions.

The sentence

(188) Charles solved the problem within 1 hour

is also ambiguous. It can be used in a discourse to say that Charles solved the problem sometime in the interval stretching forward 1 hour from the TOR. In that case, we give (188) truth-conditions:

(189) $\exists J(J \subset [TOR, TOR + 1hr] \;\; \&$ (Charles solve the problem)(J)).

But (188) can also be used to say that Charles solved the problem sometime in the past, taking not more than one hour to do so. In which case, plausible truth-conditions would be

(190) $\exists J(J \subset [START, TOU] \;\; \& \;\; dur(J) = 1\ hr \;\; \& \;\; \exists K(K \subset J \;\; \&$ (Charles solve the problem)(K)))

Thus, *within*, on this reading, has a temporal function of the form:

(191) $\exists J(J \subset I \;\; \& \;\; dur(J) = t \;\; \& \;\; \exists K(K \subset J \;\; \& \;\; \phi(K)))$

where I is, in this case, the interval [START, TOU]. We say that temporal functions having form (191) are *floating existential* functions.

We mention in passing, and parallelling the discussion of section 7.4, that *over* may arguably be used to express a temporal function not falling under either of the forms (187) or (191). Thus:

(192) Angela wrote the letter over 20 minutes

could arguably be taken to have, as truth conditions

(193) $\exists J(J \subset [START, TOU] \;\; \& \;\; dur(J) = 20\ mins \;\; \&$ (Angela write the letter)(J))

which is of the form

(194) $\exists J(J \subset I \;\; \& \;\; dur(J) = t \;\; \& \;\; \phi(J))$.

[26]Actually, this use of *for* is complicated by the fact that the intervals over which the event in question is said to have been taking place can sometimes be *summed*: that is, (184) can be taken to be true if, e.g. Angela worked on the letter over three periods of twenty minutes each. We ignore this feature of *for*, noting it as a phenomenon which does not fit neatly into the framework developed here.

But again, it is difficult to decide if the sentence (192) really should count as false if Angela took less than 20 minutes to write the letter. If so, then such *over*-sentences have the form (194), but if not, then they simply have the form (191). So it is unclear whether we should really recognize *over* as expressing a third type of floating temporal function. We leave this question open.

There are several ways to specify the reference interval I in (187) and (191). First of all, we have a wide range of temporal adverbs, as in

(195) Angela worked on the paper for four hours yesterday

where I is picked out by *yesterday*. Another possibility of special interest to us is where the temporal adverbial is itself a prepositional phrase (leading to the few cases in which it is possible to combine temporal prepositions in the same sentence):

(196) Bill has spoken on the phone for half an hour since 9 o'clock

(197) Charles will take a coffee break for 10 minutes at 10 o'clock

(198) David will work/will have worked on the lecture notes for twenty minutes by 5 o'clock

The result in each case is that the reference interval I as it figures in (187) is determined exactly as described in the preceding sections. For example, in (196), I is [9:00, TOU]; in (198), I is [10:00 - ε, 10:00 + ε]; and in (198), I is either [TOU, 5:00] or [TOR, 5:00].

All prepositions having *existential* functions in groups I to V, as described above, are able to specify I in forms (187) and (191). However, prepositions which otherwise have only *universal* temporal functions cannot be combined with *for* and *within* like this. Thus, at 9:00, it does not normally make sense to assert:

(199) ($\star$) Angela will be working on the letter for ten minutes until 10 o'clock.

(200) ($\star$) Bill will post the parcels within 10 minutes for 1 hour

except in the unusual case where the verb-phrases are treated as dispositions to perform actions repeatedly, as in behavioural psychology experiments:

(201) Angela the hamster will be pressing button A with her snout for ten minutes until 10 o'clock.

(202) Bill the rat will run through the maze within 10 minutes for 1 hour

and so on. Notice, as an aside, that we can say:

(203) Angela was working on the paper for ten minutes at 10 o'clock.

If, then, we are correct in saying that the floating use of *for* can only be combined with prepositions which, on their own, can have an existential temporal function, the above sentence provides us with a reason to say that

(204) Angela was working on the paper at 10 o'clock.

can have an existential, as well as a universal function, as was suggested in section 6.)

It follows from the truth-conditions for the floating universal temporal functions, just as with the universal temporal functions of groups I to V, that they are never satisfied for completion sentences. That is why, in sentences like

(205) Angela wrote the letter for 1 hour

(206) David hit the photocopier for 20 minutes

the underlying tenseless sentences have to receive non-completed or repeated interpretations, as discussed in section 5.

Moreover, the truth-conditions of the floating-existential functions are such that their application to non-completion sentences is redundant. Suppose ϕ is a non-completion sentence: that is, if true over an interval I, it is true over all subintervals J of I. Then any temporal function having form (191) reduces to

(207) $\exists J(J \subset I \;\&\; \phi(J))$.

So it is not surprising that

(208) ($\star$) Angela worked on the letter within 1 hour yesterday

sounds odd.[27] Evidently, our grammatical intuitions are preventing us from making statements that we could otherwise make more simply.

Choice of tense and aspect is described easily enough. Subject to the provisos mentioned below, it is simply the choice that would be made were the floating-prepositional phrase to be omitted—i.e. the choice that would be made to express the corresponding (and weaker) truth-conditions (207). In those cases where I is determined by means of an additional prepositional phrase as in (196), (198) and (198), those rules have been given. When I is fixed only by tense or is fixed by some other temporal adverbial, then other tense-selection rules apply, but tense-selection rules in general fall outside the scope of the present paper.

The provisos just mentioned concern a couple of anomalies involving the progressive. First of all, the progressive, since it results in a non-completion sentence, is banned from floating existential functions. Thus

(209) ($\star$) Angela was writing the letter within 1 hour yesterday

sounds odd (but see footnote after (208)).

Secondly, the progressive may interact in a special way with *by*, *at* and *in*. For it is possible to say:

(210) By 10 o'clock, David will have been working on the paper for 1 hour

[27]Sentence (208) is acceptable if used to mean, for example, that Angela worked on the letter *within an hour of arrival*. It is not clear how to treat this usage, though the obvious move would be to try to assimilate it to the anaphorical forward-looking group-I use of *within*.

(211) At 10 o'clock, David will have been working on the paper for 1 hour

(212) In 5 minutes, David will have been working on the paper for 1 hour

implying that he has at least been continuously working on the paper from 9:00–10:00 (if the last of these is uttered at 9:55). Notice the difference if the progressive is omitted

(213) By 10 o'clock, David will have worked on the paper for 1 hour

The implication that David spent the hour leading upto 10:00 working on the paper disappears.

If the suggested implication of cases such as (210) is recognized as being part of the truth-conditions of these sentences, then we have a usage of *by*, *at* and *in* with *for* for which the above treatment has no account. But this usage does seem to be singular. In particular, reversing the order of quantification is impossible (i.e. changing *by* into *until* and *for* into *within*):

(214) $\star$ Until 10 o'clock, David will have worked/been working on the paper within 10 minutes.

Moreover, reflecting the time axis about the TOU is also impossible (i.e. changing *by* into *since*), since

(215) $\star$ Since 9 o'clock, David was working on the paper for 1 hour

is incorrect (*since* requires a perfective), and

(216) Since 9 o'clock, David had been working on the paper for 1 hour

although it could be used in certain circumstances, does not clearly mean that David worked throughout the interval [9:00, 10:00]. So there is reason to treat (210)–(212) as maverick cases.

9 Conclusion

In this paper, we have charted the expressive power of the English temporal preposition system by determining the forms of the temporal functions—functions mapping underlying tenseless sentences onto propositions—which those prepositions can express. We distinguished just four such forms, namely:

(217) $\exists J(J \subset I \ \& \ \phi(J))$

(218) $\forall J(J \subset I \rightarrow \phi(J))$

(219) $\exists J(J \subset I \& dur(J) = t \ \& \ \exists K(K \subset J \ \& \ \phi(K)))$.

(220) $\exists J(J \subset I \ \& \ dur(J) = t \& \forall K(K \subset J \rightarrow \phi(K)))$

and, more doubtfully two additional forms:

(221) $\phi(I)$

(222) $\exists J(J \subset I\ \&\ dur(J) = \mathrm{t}\ \&\ \phi(J))$.

We saw how the parameters I and t are fixed in a number of ways, using, as well as the prepositional arguments, indexical, anaphorical and other contextual parameters. Ignoring the doubtful cases, we distinguished five groups of temporal functions having forms (217) and (218). These are: 16 group-I functions, where one of the bounds on the reference interval I is fixed at either the TOR or the TOU; 12 group-II functions in which the reference interval I is some sort interval straddling a time point specified either absolutely or relative to the TOU or TOR; 4 group-III functions in which one bound of the reference interval is either the start or the end of the temporal universe of discourse; 2 group-IV functions in which the endpoints reference interval are given directly by a pair of arguments; and 2 group-V functions in which the reference interval is given by a single argument. In total, then, we have 36 temporal functions of forms (217) and (218)—that is: 2 temporal forms, each with 18 ways of specifying the reference interval I. In addition, we distinguished a final group of floating functions having forms (219) and (220)—each with an indeterminate number of ways of specifying I. We investigated how temporal prepositions span this logical space by combining with tense and aspect, and we explained how the well-known restrictions on the use of temporal prepositions with underlying tenseless sentences of various aspectual classes arise.

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