Towards a formalization of the semantics of some temporal prepositions

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Abstract

Many prepositions can be used to convey temporal information relevant to the period of a proposition. Three types of information are identified: the duration of the proposition (floating), its duration relative to the time of reference of the discourse and its absolute location on the time axis. Some prepositions can be used in all three manners, others in only one; rules are given for determining in which manner the former are being used in any given sentence. Within each manner, there are several different possible uses to which temporal prepositions are put. These uses distinguish between existential and universal quantification over time, indicate whether or not the extremes of the period are to be included and mark for motion through time. To capture these, a semantics for the 9 temporal prepositions indicating periods, is provided using the first-order predicate calculus. An explanation is proffered for why some of these uses can be filled by two prepositions.

Time, you old gypsy-man, will you not stay,
Pack up your caravan, just for one day?

What does FOR 'do' in this quotation from Ralph Hodgson (b.1872)? It is being used to fix the duration of the *packing up* to be one day - for the whole of the day, not just for part of it. It looks as though FOR is a universal quantifier over a length of time.

What would happen to the meaning of the sentence if FOR were to be replaced by one of the many other temporal prepositions, such as IN, DURING, BY, THROUGH, THROUGHOUT, OVER, AGO or WITHIN? For instance:

Pack up your caravan, just IN *one day?*
Pack up your caravan, just DURING *one day?*

With IN the *packing up* activity should be completed in one day rather than the state of *being packed up* lasting throughout the day. With DURING the intention is not clear: both the completion or lasting interpretations seem possible. For the other temporal prepositions *just* must be moved or dropped and different meanings seem to result:

Pack up your caravan, THROUGHOUT *one day?*
˜*Pack up your caravan,* THROUGH *one day?*
Pack up your caravan, OVER *one day?*
?*Pack up your caravan, one day* AGO?

NB

* is used to indicate that the alternative preposition cannot be used,

˜ is used to indicate that the alternative preposition alters the meaning of the original sentence.

To write a computer program to be able to understand such sentences by whatever measure one cares to take, one needs to have some representation in which the meaning of a sentence can be deduced from the meaning of its constituent words and phrases. As a complement, to have a computer program that will produce sentences which convey the meaning of a 'thought', then one needs to have a mapping that will take the parts of the thought into words and phrases. In this paper we are interested in a small portion of this puzzle: the mapping between prepositions that are used to indicate the period in which something is the case and the extent and location of this period in time.

The main question that is addressed is: can a semantics be provided that distinguishes between those temporal prepositions which are used to indicate periods of time that is an improvement on previous attempts, such as those of Bennett [1975], Miller & Johnson-Laird [1976], Röhrer [1977], Kamp[1981], Allen [1984] and Richards et al [1989]. This question stems from a research programme [Brée & Smit 1987; Durrell & Brée 1992] aimed at answering more general questions such as: why does it seem to be the case that there are more such prepositions than would be needed simply to establish that an event falls in a period (naively, just one - e.g DURING - should logically be sufficient here) and yet why do so many prepositions seem to get used in multiple ways?

Here, we ignore the role of tense and aspect except where it is necessary in order to distinguish between the different uses to which the temporal prepositions for periods are put, as we deal with this elsewhere [Pratt & Brée 1992]

1 Introduction

Temporal prepositions are used in two main ways: with an indefinite noun phrase to indicate a duration of time, say *five minutes*, and with a definite noun phrase to indicate a period of time on the time axis, say *1992*.

Figure 1, taken from earlier work [Brée 1992], shows a taxonomy of those temporal prepositions that can be used with an **indefinite** noun phrase to indicate a duration of time. Note that the abbreviation M indicates the meaning of the matrix clause in which the temporal prepositional phrase is

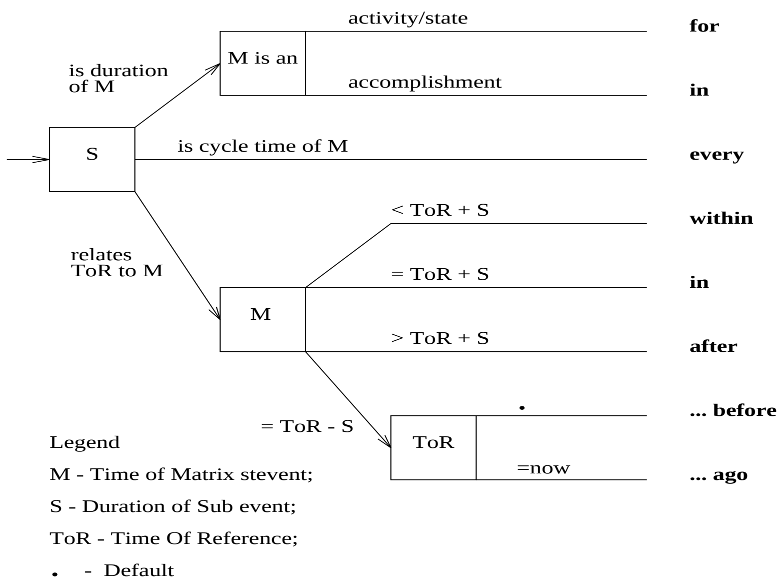


Figure 1: English durative temporal prepositions

embedded and S indicates the length of time indicated by the noun phrase subordinate to the temporal preposition. For example, in the above quotation:

M = Time packing up his caravan
S = one day

There are three main durative uses, shown in Figure 1, emanating from the left most box labelled S . The first use simply sets the duration of the event described in the matrix clause in which the prepositional phrase is embedded to be equal to S; we will call this the **floating** use. The second use is to indicate a matrix event that repeats with a certain frequency, it is not covered in this paper. This gives us the prepositions FOR, IN, WITHIN, BY and AGO. The third use indicates that the time of the matrix event is in a period adjacent to the Time of Reference (ToR) of the discourse, in the sense of Reichenbach [1947]; we will call this the **relative** use. AFTER and BEFORE will not be analysed here; they are also subordinating conjunctions.

Figure 2, taken from the same work, is a taxonomy of temporal prepositions used with a **definite** noun phrase to indicate that the matrix event is located at a position on the time axis; we will call this the **absolute** use. In this paper we will only consider a small portion of this taxonomic tree, namely the part in which the time of the matrix event is placed directly in a period introduced by the prepositional phrase. This covers only the prepositions: DURING, IN and FOR. Some further temporal prepositions serving the same function but not included in the original, are also covered, namely: THROUGH, THROUGHOUT and OVER.

To ensure that none of the different temporal uses of these 9 prepositions were missed, we had recourse to a sample of sentences taken from the Brown corpus of one million words of text sampled from sources of American written texts [Kučera and Francis, 1967]. To indicate the semantic differences between these prepositions, examples have been chosen from the sample which permit one but not another preposition to be used. These examples are accompanied in this paper by the sequence number of the sentence in the Brown Corpus. The total number of occurrences in the corpus of the 9 prepositions in which we are interested is about 30,000, i.e. about 3% of the words. One of these prepositions occurs in almost every sentence in the corpus! Over half the instances are of IN and a quarter are of FOR. Because of the large numbers of sentences containing these two prepositions, we have sampled 19% and 65%, respectively, of the sentences containing them. For the other 7 prepositions we have looked at all sentences in which they occur. 'Looking at' entailed, in the first instance, deciding whether or not the preposition was being used in a temporal manner. The percentage of occurrences found to be temporal varies, as shown in Table 1, but is generally low, except for DURING and AGO which are only used temporally.

Table 1: Number of occurrences of these temporal prepositions in the Brown corpus

Preposition	ago	by	during	for	in	over	thr'	thr'out	within	Total
Nr in sample:										
temporal	229	125	424	261	249	83	55	26	48	1500
total	245	4520	429	5072	2919	1170	906	122	319	15703
% temporals	93	2	98	5	8	7	6	21	15	9
Nr in corpus:	245	4520	429	7804	15366	1170	906	122	319	30881
% sampled	100	100	100	65	19	100	100	100	100	50

For each of the sentences in which the preposition was deemed to be used

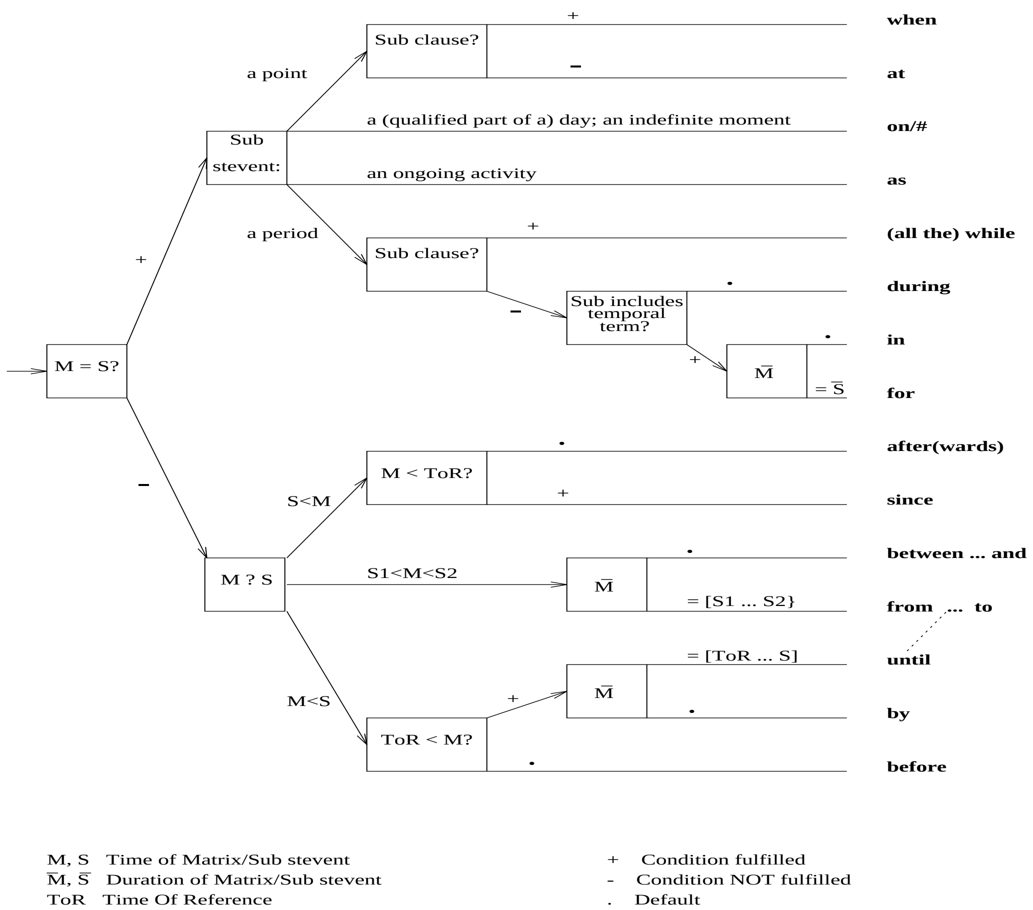


Figure 2: English non-durative temporal prepositions

temporally, the noun phrase following the preposition was examined. The noun phrase was, in the first instance, classified as being either definite or indefinite, e.g. *the summer* versus *five minutes* respectively. Further, classification into the type of noun in the noun phrase was also made, but will not concern us here. Further the aspect and the modal of the verb in the matrix clause was also noted, if present. If the matrix clause was itself a noun phrase, e.g. *...the banks* IN *the 19th century ...* then this classification could of course not be made. The use of verbal aspect and modal plays a part in determining when an indefinite temporal noun phrase is being used relatively rather than simply floating.

We now analyse in turn each of the three main different types of use of temporal prepositions:

floating to indicate the duration of a matrix event,

relative to place the time of the matrix event within an interval adjoining the ToR,

absolute to place the time of the matrix event in the period specified directly by the prepositional noun phrase.

Finally, we will note some other temporal uses specific to some of these same prepositions.

To analyse the difference between closely related pairs of prepositions, we will look for sentences in the sample in which one or the other preposition is used but the other one cannot be. The meanings of such sentences are then used to construct the formal specification of the semantics for the pair of prepositions.

2 Floating use

In the original analysis, see Figure 1, only two prepositions are shown that indicate the floating duration of the matrix event: FOR and IN. Here we will also look at WITHIN, BY and OVER as they were also found to introduce a floating length of time. We turn to our first pair of closely related prepositions: FOR and IN.

2.1 FOR versus IN

The traditional difference between FOR and IN is that FOR is used when the matrix verb is an activity or state whereas IN is used when the matrix verb is an accomplishment:

232 FOR/IN* *years he wore hand-me-down suits ...*

211 *...this miracle was accomplished* IN/FOR˜ *decades rather than centuries ...*

However, this distinction is difficult to capture in a formal system. Herweg [1991] has proposed that the difference is that with FOR the duration of the matrix event must be at least as long as the time indicated in the prepositional phrase, whereas with IN the matters are the other way around. This can be seen in the examples. 232 and 211 hold if it is the case that:

232' *The length of time that he wore hand-me-down suits was 2 decades.*

211' *The length of time that it took to accomplish this miracle was 2 years.*

respectively, but not if:

232" *The length of time that he wore hand-me-down suits was 1 month.*

211" *The length of time that it took to accomplish this miracle was 2 centuries.*

respectively. Formally this can be expressed as:

For:: duration(M) $\geq$ S,

In:: duration(M) $\leq$ S.

While this difference is correct, it fails to capture other differences between FOR and IN. Consider a case when John painted his house for exactly 3 weeks, and compare:

John painted his house FOR *three weeks.*

John painted his house IN *three weeks.*

both of which are true by the above definitions. However, it is still the case that with IN there is an implicature that the painting of the house was complete, whereas with FOR there is not. So the definition[1] of this use of these temporal prepositions will be:

For:: duration(M) $\geq$ S;

In:: duration(M) $\leq$ S & complete(activity(M))=True.

2.2 WITHIN

WITHIN indicates that the duration of M is definitely less than S. It is almost always used to indicate a period relative to some event (for use relative to the ToR, see below) as in:

13768 *...nearly 40 per cent of those who joined the Church were lost to the Church WITHIN seven years.*

where the loss occurs in a period less than or equal to 7 years of becoming a member. However, we will ignore this complication here and define floating WITHIN as:

Within:: duration(M) $<$ S & complete(activity(M))=True.

2.3 Over

Over differs from both in and for, e.g.:

23051 *...roads ... are investments which pay their own way* over/in˜/for˜ *a period of years ...*

If over were replaced by in in 23051 then the "paying their own way" could take place at any time in the "period of years" rather than throughout the period. If over were replaced by for then the sense is completely altered to indicate that the "paying their own way" is true for a certain number of years, presumably in each year, with the implicature that this then ceases after the period is over. This suggests that the duration of the matrix event is set to be equal to the length of time indicated by the noun phrase.

Over:: duration(M) = S

2.4 By

The preposition by is unusual as it contrasts with until and since (see Figure 2), both of which cannot take a floating duration, whereas by can:

28137 *Hardy's two productive decades were separated* by/˜until/˜since *40 years ...*

However, it does so only when the verb in the matrix clause indicates that there is some difference:

John painted his house by* *three weeks.*

The examples of verbs having this property in the corpus include: *loose, separate, shorten.* So by introduces a length of time by which the duration of an activity or state in the matrix clause is being changed. We propose the following definition:

By:: difference(M) = S.

This completes the analysis of the use of IN, WITHIN FOR, OVER and BY to introduce a pure duration. We see that the duration of the matrix can be set to be more than (FOR), equal to (OVER), less than or equal to (IN) or definitely less than (WITHIN) the time duration indicated by the prepositional phrase. When the relationship is one of less than, then the matrix must be a completed activity. Rather different is BY, which is used to provide the time by which some activity or state in the matrix is changed.

We now turn to the use of prepositions to indicate a time relative to the ToR.

3 Periods relative to the Time of Reference

The more usual use of a length of time in the noun phase is to indicate the time of the matrix event **relative** to the ToR. The time period can either end or begin at the ToR.

The usual way to show that the time duration specified in the prepositional phrase **ends** at the ToR is to use the perfect aspect. This effect is also achieved when the prepositional phrase occurs within an AFTER clause and with comparative constructions:

3571 *We've been working* FOR *weeks.*

6363 *After being a lawyer* FOR *25 years he started studying for the ministry.*

4900 *This is the first time* IN *100 years that ...*

To indicate a period **starting** at the ToR, a modal is used. Whereas a perfect aspect always indicates that the length of time is to precede the

ToR, a modal is not always sufficient to indicate the length of time follows the ToR. Often an adjective in the prepositional phrase helps to do this, e.g. *coming, following, next.*

Three of the five prepositions we have just discussed with floating duration are used this way: FOR, IN and WITHIN. We begin by comparing them and then go on to analyse an adverb that is closely allied: AGO.

3.1 FOR versus IN

We have seen that, with floating durations, M FOR S is true when duration(M) $\geq$ S whereas IN can be used when duration(M) $\leq$ S. Just as with floating durations the contrast can be specified as a constraint on the range of time for which the matrix event must hold. With FOR it must be for at least the length of time given in the prepositional phrase, whereas for IN it must be for no more than this time. For example the sentences:

18812 *"I had known him* FOR/IN* *some years, ...*

44 *Two things have happened* IN/FOR* *recent months to ...*

would hold if:

18812' *The period of time I had known him is the 5 decades before now.*

44' *The period of time in which the two things happened is the week prior to now.*

respectively. But more interesting is that with FOR the matrix event is required to occupy the whole of the interval indicated whereas with IN the matrix event must simply occur at some point within this interval, i.e. FOR is a universal quantifier whereas IN is an existential quantifier. This suggests that we adopt the following definitions in the context of a period relative to the ToR

For|ToR-:: $\forall$T (T$\subset$[ToR-S, ToR] $\rightarrow$ occ(M,T))

In|ToR-:: $\exists$T (T$\subset$[ToR-S, ToR] & occ(M,T))

where "|ToR-" is used to cover any context which leads to an interpretation requiring the time period to end at the ToR, i.e. the perfect aspect, within an *after* clause or a comparative. These are to be read as: For all/one time interval(s), T, in the range from the ToR less the length of time indicated by the noun in the temporal preposition phrase, up to and including the ToR, it is the case that M occurs at T.

When we look at the sentences in which the length of time is used to indicate the time period **starting** rather than finishing at the ToR, matters are, surprisingly, somewhat different. With FOR the situation is symmetric with a period ending at the ToR, but with IN the matrix event is set to occur at the end of the period beginning at the ToR rather than at some time within this period:

10655 *Here they would lie in suspended animation* FOR *many years.*

195 *And when they sell it to television* IN *a couple of years, ...*

Note that the *selling* will not be taking place at some time in the period between now and two years from now but rather after a lapse of two years. So we propose the following different definitions for FOR and IN with a modal matrix verb indicating that the length of time is to follow the ToR:

For|ToR+:: $\forall$T (T$\subset$[ToR, ToR+S] $\rightarrow$ occ(M,T))

In|ToR+:: $\exists$T (T=ToR+S & occ(M,T))

where "|ToR+" indicates that the preposition occurs within a context in which the time period is to start at the ToR, i.e. a modal.

3.2 IN versus WITHIN

The role which IN 'lost' for the period **after** the ToR is taken by WITHIN:

23353 *This bill should be paid* WITHIN/IN *30 days.*

WITHIN can also be used for a period ending at the ToR, in which case its difference with IN appears to be small[2]. Only if the prepositional phrase indicates that the whole of the period is involved, for instance when it is a negation, is WITHIN not suitable:

44 *Two things have happened* IN/WITHIN *recent months to ...*

38 *Those elegant "At home" cards she sent out ... hadn't brought many callers* IN/WITHIN* *two whole months.*

This suggests the following definition for WITHIN:

Within|ToR-:: $\exists$T (T$\subset$[ToR-S+ϵ,ToR] & occ(M,T))

Within|ToR+:: $\exists$T (T$\subset$[ToR,ToR+S-ϵ] & occ(M,T))

where ϵ is some small length of time.

3.3 AGO

Finally we turn to AGO, which is not classified by dictionaries as a preposition but as an adverb. However, it has similar properties to the prepositions that we have been discussing and cannot be used to modify adjectives and verbs in the way that adverbs can. So we have included it in the analysis, preferring to think of it as a post-position rather than as an adverb. It is similar to the use of IN to indicate an elapsed time beginning at the ToR. AGO is used to indicate that the matrix event occurred at a point of time before the ToR by an amount given by the noun in its 'phrase':

5112 *"A year* AGO *I took the grips of the plow* (sic) *in my hands."*

All occurrences of AGO in the corpus have this structure, governing a length of time in the context of a matrix verb with perfect aspect. So the definition that we give is:

Ago:: $\exists$T (T=ToR-S & occ(M,T))

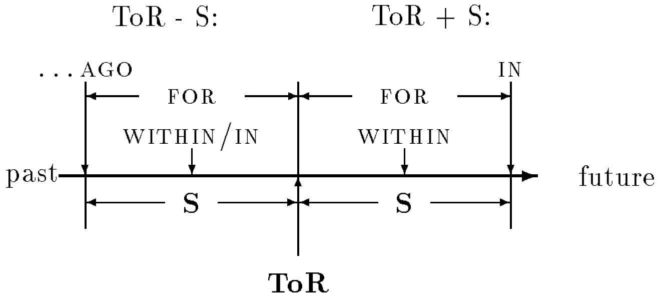
3.4 Summary

Table 2 gathers together the definitions for the relative use of the temporal prepositions in the context of either a perfect aspect or of a modal together with any adjective in the prepositional phrase. They are illustrated in Figure 3.

Table 2: Summary of the relative use of prepositions.

Matrix	has perfect aspect (ToR-)	has a modal (ToR+)
For	$\forall$T(T$\subset$[ToR-S,ToR] $\rightarrow$ occ(M,T))	$\forall$T(T$\subset$[ToR,ToR+S] $\rightarrow$ occ(M,T))
In	$\exists$T(T$\subset$[ToR-S,ToR] & occ(M,T))	$\exists$T(T=ToR+S & occ(M,T))
Within	$\exists$T(T$\subset$[ToR-S+ϵ,ToR] & occ(M,T))	$\exists$T(T$\subset$[ToR,ToR+S-ϵ] & occ(M,T))
Ago	$\exists$T(T=ToR-S & occ(M,T))	–

Figure 3: The temporal prepositions with an indefinite noun phrase, indicating a period before or after the Time of Reference.



In words, we see that FOR is used to indicate that the matrix state or activity occupies all of a length of time either before or after the ToR; that WITHIN is used to indicate that the matrix event occurs in a length of time either before or after the ToR that is less than S; that IN is similar to WITHIN for lengths of time **before** the ToR but indicates that an event occurs **at** a point in the distance S **after** the Tor; and complementing this, AGO is used to indicate that an event occurs at a point of time **before** the ToR. Finally the perfect aspect of the matrix verb is used for periods before the ToR and a modal is used for periods after the ToR.

4 Absolute use

The prepositions that can take a definite noun phrase to indicate directly a position on the time axis that is a period (as opposed to a point) include not only FOR, IN and DURING, as shown in Figure 2, but also THROUGH, THROUGHOUT and OVER. We again examine the differences between pairs of these prepositions by looking for sentences in the corpus sample in which one but not the other may be used. The most salient distinction is between existential and universal quantification, but clearly this is not sufficient to account for all the differences between these six prepositions. We need to have additional features which will lead to the choice of one or the other of the six in any given situation.

4.1 FOR versus IN

We have already seen that the contrast between FOR and IN is not the same in the floating and relational uses. In the floating use, IN indicates that the matrix event is completed, whereas FOR leaves this open. In the relational use, FOR is a universal and IN an existential quantifier. The two are of course linked in that accomplishments are likely to be completed within the time duration, whereas activities naturally last for the whole of a period. When the prepositional noun phrase is definite, indicating an absolute period on the time axis, the same distinction appears to hold. Consider:

2712 *... our kids* FOR/IN* *the third straight week stayed in there pitching ...*

1964 *Seidel joined the department* IN/FOR* *1964 ...*

FOR indicates universal quantification of a non-accomplishment; IN indicates an existential quantification of an accomplishment. This holds for all the IN examples (of which by far the majority have a specific year as the noun phrase). This suggests the following definitions:

For:: $\forall$T (T$\subset$S $\rightarrow$ occ(M,T))

In:: $\exists$T (T$\subset$S & occ(M,T))

If IN gives the existential quantification and FOR the universal quantification, what room is there left for the remaining temporal prepositions that take a period? We look at each of the remaining four prepositions in turn with this question in mind.

4.2 FOR versus THROUGHOUT

FOR is not the only indicator for universal quantification with a absolute time; there is also THROUGHOUT:

24889 *But they ... remain there* THROUGHOUT *the summer, fall and winter.*

So we define THROUGHOUT also to be a universal temporal quantifier that can only be used with absolute time:

Throughout:: $\forall$T (T$\subset$S $\rightarrow$ occ(M,T))

What is strange is that there are two such universal quantifiers for absolute use, FOR as well as THROUGHOUT. Moreover, the two are not always interchangeable!

Replacing FOR by THROUGHOUT is often unacceptable:

11150 *Kennedy invited Stevenson to Cape Cod* FOR/THROUGHOUT~ *the weekend.*

Here THROUGHOUT forces the invitation to be given repeatedly over the weekend rather than indicating that the weekend is the object of the invitation. There are several such cases in the corpus, mostly where there is a verb (e.g. *cancel, invite, plan, prescribe, protect, schedule, set*) or noun phrase (e.g. *at home, function, hope, need, prospects, research and development*) indicating that there is a goal to be achieved.

There are also other related uses of FOR which are not shared by THROUGHOUT. One is when a time period possesses something:

18856 *I' ve looked through back-issue files of New York papers* FOR/THROUGHOUT~ *December , 1957 ...*

5141 *Open crowns , went on to win a record $ 80,738* FOR/THROUGHOUT* *the year.*

These other functions of FOR can also occur without a temporal noun phrase, e.g. *plan for a downturn, a record for the company.* So in such cases we consider FOR as being used to perform these other functions, rather than being used temporarily; it just happens to have a temporal noun phrase.

The same multiple use is not found with THROUGHOUT, so one would not expect there to be so many instances in which THROUGHOUT cannot be replaced by FOR. But on the contrary, replacing THROUGHOUT by FOR almost always results in complete failure, sometimes to a different interpretation and only rarely to no change in meaning!

54222 *This theory makes it possible for any event* THROUGHOUT/FOR* *eternity to be ...*

37855 *Palfrey was concerned about what wage to pay for their labor* THROUGHOUT/FOR~ *1844.*

In these cases the use of FOR rather than THROUGHOUT results in one of the non-temporal uses of FOR being elicited. This suggest that THROUGHOUT is chosen for a universal absolute temporal use in preference to FOR only when FOR, if used, would have been given one of its non-temporal interpretations. This suggestion remains to be tested on the corpus data.

4.3 THROUGHOUT versus THROUGH

If THROUGHOUT is one of the universal quantifiers over temporal periods, what is the role for simple THROUGH? Universal quantification is called for in most cases and it is sometimes possible to replace THROUGHOUT by THROUGH:

3947 *Werner said yesterday that operations continued* THROUGH *the week.*

24889 *But they ... remain there* THROUGHOUT/THROUGH *the summer, fall and winter.*

However, generally, replacing THROUGHOUT with THROUGH is impossible or alters the meaning of the sentence:

54222 *This theory makes it possible for any event* THROUGHOUT/THROUGH* *eternity to be ...*

37855 *Palfrey was concerned about what wage to pay for their labor* THROUGHOUT/THROUGH˜ *1844.*

One might expect that THROUGH could be replaced by the existential quantifier IN. This agains turns out **not** to be the case:

21015 *As they move* THROUGH/THROUGHOUT*/IN* *the college years our young men and women are "socialized" into ...*

5386 *The carrots sometimes don't make it* THROUGH/THROUGHOUT*/IN˜ *the winter;* [3]

In fact most of the instances of THROUGH in the sample occur in a matrix with a verb having an element of motion, e.g. *crawl, fall, guide, lead, live, make it, move, pass, take.* This is not surprising when one remembers that spatial THROUGH requires the movement from one side of an object to the other, as in *throw the stone through the window.* This aspect of the meaning of THROUGH is difficult to capture in any standard formalism of time.

We propose that THROUGH **does** require universal quantification but in addition expects some movement through time from the beginning to the end of the time period indicated in the temporal prepositional phrase. Again a formal definition is difficult to give. Maybe:

Through:: $\forall$T (T$\subset$S $\rightarrow$ occ(M,T)) | action(M, motion)

will do, where the part after the vertical bar, |, is a condition for the use of the preposition rather than part of its truth conditions.

We have now completed the analysis of the temporal prepositions used to indicate universal quantification over a period of time at some position on the time axis. We turn now to OVER for which it is not clear whether it is universal or existential.

4.4 OVER

The Oxford English Dictionary indicates that the temporal use of OVER may be either universal ("for the duration of") or existential ("at any point during the course of"). The choice depends on the matrix verb; for example *stay over the weekend* is universal, *do it over the weekend* is existential. Examples from the corpus confirm this duality:

9616 *If the plants are cared for and protected* OVER/THROUGHOUT/IN *the winter, ...*

50456 *They were married* OVER/THROUGHOUT*/IN *the weekend, ...*

In 9616 it is essential that the protection last for all the winter, which points to a universal quantification; in 50456 it is unlikely that the marrying lasted all the weekend, which requires an existential quantification. If we try substituting THROUGHOUT and IN to test for universal versus existential quantification, we see that 50456 must indeed be existential, whereas 9616 does not require a universal temporal preposition. This suggests that OVER is in fact existential and that the universal interpretation of 9616 comes from the nature of the matrix verb, protection being ineffective if it is not continuous.

Substituting IN (existential) for OVER in all the normal uses of OVER throws up no anomalies. All that can be said is that OVER is more appropriate, e.g.

40630 *A terse and stereotyped verbal expression ... reveals itself* OVER/IN *the months of therapy as ...*

What OVER contributes over and above simple IN, is a sense of development during the course of the period specified by its noun phrase. However, even this is not always present, e.g. 50456.

When we try the reverse substitution of OVER for IN, the substitution does not always work!

1964 *Seidel joined the department* IN/OVER* *1964 ...*

6695 *... The sailing* IN/OVER* *the spring of 1610 was Hudson's fourth in four years.*

4216 *... Sarkees graduates from Eastern High School* IN/OVER* *June.*

4915 *... at one point* IN/OVER* *the afternoon ...*

One reason is that OVER only takes a proper noun when it is being used to compare a property of one time period with another, one of its special uses (see below), so all the many examples of IN used with a year cannot take OVER. Similarly OVER is not acceptable when a specific season, day or part of a day is the time period in question. On the other hand OVER can take a time phrase such as *the years* or the *the X years* where the *X* stands for some qualifying adjectival:

2238 *It will become an acute problem* IN/OVER *the coming fiscal year.*

1164 *What awful thing had she to face* IN/OVER *the next few hours?*

Specifying precisely these restrictions is beyond the scope of this paper. So we content ourselves with a definition which restricts the felicitous use of OVER to a period of time specified without a proper name:

Over:: $\exists$T (T$\subset$S & occ(M,T)) | S is not specified using a proper noun

Clearly this is not satisfactory from a formal point of view, but it does give some indication of where to look for improvement.

4.5 DURING versus IN

The last preposition that we cover is the frequently used DURING, which can only be used temporally. It is existential rather than universal, and so to be compared with IN and OVER:

39622 *Sherlock Holmes ... was born* DURING/IN/THROUGHOUT* *the 1890s.*

28877 *... a great number of complex compounds ... have been obtained in this laboratory* DURING/IN/THROUGHOUT* *the past fifteen years.*

The difference between IN and DURING appears to be only that DURING can take non-temporal noun phrases and still give a temporal specification to its matrix sentence, whereas IN cannot, cf

9507 *I have not seen this change made* DURING/IN~ *my stay here.*

19444 *They would all lie around on the rug* DURING/IN~ *the meal.*

There may be other differences between the two which may reveal themselves on further examination of the examples, but they are not obvious. So the definition we give to DURING is identical to that of IN:

During:: $\exists$T (T$\subset$S & occ(M,T))

4.6 Summary

This brings us to the close of the comparison of the absolute use of these temporal prepositions. An overview is given in Table 3

Table 3: Summary of use of the absolute use of prepositions.

For	$\forall$T(T$\subset$S $\rightarrow$ occ(M,T))	
Throughout	$\forall$T(T$\subset$S $\rightarrow$ occ(M,T))	
Through	$\forall$T(T$\subset$S $\rightarrow$ occ(M,T))	|action(M, motion)
In	$\exists$T(T$\subset$S & occ(M,T))	
During	$\exists$T(T$\subset$S & occ(M,T))	
Over	$\exists$T(T$\subset$S & occ(M,T))	| S is not specified using a proper noun

We have seen that FOR, THROUGH and THROUGHOUT all indicate that the matrix state or activity lasts for the whole of the period given in the prepositional phrase. Through is only used when the matrix activity involves motion. In contrast IN, DURING and OVER indicate that the matrix events occurs at some time within the period given by the prepositional phrase. Over can only be used when the noun in its prepositional phrase is not a proper noun. Also, when the prepositional phrase indicates some activity or state rather than a time interval, then DURING must be used rather than IN.

This completes the analysis of the three standard uses: floating, relative and absolute. However, some of these same prepositions have temporal uses peculiar unto themselves.

5 Special uses

Some of the nine prepositions for which we have just given an analysis of their normal temporal use also have special temporal uses. These uses are special in the sense that the interpretation is in addition to the normal use and is called for under particular circumstances. Here these uses will just be mentioned but not analysed.

By is also used to indicate the rate at which the matrix event is taking place. It occurs if and only if the noun phrase is a definite unqualified temporal duration:

20520 *... the relationship grew colder* BY *the day ...*

Over can also indicate a comparison between a value of some attribute compared to what it was at some previous time. It occurs only when the noun phrase is a proper time:

23094 *... an increase of $ 187 million* OVER *1960,*

There is a use of OVER to indicate *greater than*, which can be easily confused with a temporal use when its noun phrase is temporal, and precautions will have to be taken to avoid giving OVER a temporal interpretation in these cases:

39404 *For* OVER *a hundred years Southerners ...*

Through can be used with a proper temporal noun in American English to indicate a period up to and including the period given in its noun phrase:

21867 *From 1 July 1960* THROUGH *31 January 1961,*

This concludes our list of special uses.

6 Summary

The definitions that we have given in this paper are collected together in Table 3. For completeness, this table includes a definition for the absolute use of BY, although it has not been introduced in the discussion above. This use of BY takes us beyond the scope of this paper; it needs to be compared with prepositions that take an absolute time and indicate a period beginning or ending at the ToR, such as UNTIL and SINCE, which we have done elsewhere [Brée 1985].

The sample from the Brown corpus has enabled us to detect differences in the meanings of all these 9 temporal prepositions indicating a period. The rationale for having so many prepositions becomes clear. The following differences underlie the schema of Figure 3:

- Universal versus existential quantification over the period: FOR, THROUGHOUT, THROUGH versus DURING, IN, WITHIN, AGO, OVER, BY;
- When there are multiple uses of a preposition that could lead to ambiguity, then a second preposition is required. With universals THROUGHOUT rather than FOR; with existentials DURING rather than IN;
- Excluding the extremes of the period, i.e. WITHIN rather than IN;
- The context of motion may require a specialised preposition: THROUGH rather than THROUGHOUT, OVER rather than IN.

This table gives the formal semantics of these 9 temporal prepositions that we were looking for when we started this paper. Using these definitions temporal information can be incorporated into propositions representing the meaning of English sentences. Vice-versa, given propositions which incorporate temporal information, the appropriate temporal preposition can be selected for insertion into a sentence that is being used to express this preposition.

To improve this analysis, account needs to be taken of the interaction with the tense and aspect, including the progressive, a task which we have carried out elsewhere [Pratt & Brée 1992]. In addition the remaining temporal prepositions in Figures 1 and 2 need some further attention, in particular AT, ON and IN. Further, this preliminary analysis of the Brown corpus shows that the types of noun phrases that are permitted with the different, prepositions are interesting and require explanation.

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Notes

[1]A counter argument to this definition hinges on an alternative perspective, namely that the matrix activity holds for every subinterval with FOR but not with IN. This would suggest, for example, that M should be true for every subinterval of S with FOR but not with IN. However, this only applies to intervals on the time axis, which we deal with in the next section, and not to floating lengths of time.

[2]All the examples of IN indicating a period ending at the ToR are either comparisons, as 4900, or have a perfective aspect **together with** an adjective (*recent*) qualifying the length of time, as 44, or a negation, as 38. This suggests that it is not so 'natural' to use IN to indicate a period before the ToR, either.

[3]This example involves a negation in the matrix, which introduces a negation scoping problem (does the THROUGH phrase fall within or outside the scope of the negation?) which may explain why it appears not to require universal quantification.