

A GUIDE TO THE LOGIC OF TENSE AND ASPECT IN ENGLISH

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The last few decades have witnessed the birth and growth of tense logic. One of the leaders in that field was Richard Montague, cf. Montague (1968). During this development, Montague took an increasing interest in linguistics. Between 1968 and 1970, he wrote a series of important papers in which he proposed, and to some extent demonstrated, that English can be regarded as a formal language. For logicians, a formal language has a rigorously defined syntax and semantics. The formalism provides a characterization of the notions of a true sentence (under a given interpretation) and of logical consequence. Montague took a model-theoretic approach to giving a semantics for a natural language, and thus he regarded the task of defining the above notions as central. He did not attempt to show that all of English is a formal language. Instead, he constructed «fragments of English», formal languages that involved only a very limited range of syntactic constructions. He imagined that further research would consist in refining and extending these fragments to include more and more of the wide variety of syntactic structures in English.

There are three papers where such fragments are presented: Montague (1970 b), Montague (1970 c), and Montague (1973) (henceforth PTQ).

The analysis of tense in these fragments is in the manner of tense logic. He analyzes only three of the tenses, and even in these cases, his treatment is rudimentary. In carrying out Montague's program, one would want to treat all of the tenses, in all of their complexity, within a fragment. In other words, one would want to formalize the logic of tense and aspect in English. I say «the logic» because I am optimistically assuming that there is a unique such logic that remains to be described. But at present, the situation looks very complicated

and formidable—many would say hopeless. This paper describes what I take to be the central problems and outlines a solution. Although my discussion will be informal, I believe that it can be completely formalized. That is, I believe that these ideas can be implemented within a fragment.

We will approach our subject by considering two puzzles. One of them concerns Montague's treatment in his fragments of the simple present tense. The other puzzle is the problem of giving an analysis of the present progressive tense. After presenting the puzzles, I shall attempt to account for them. First we will consider two solutions that turn out to be defective. Then we will consider a modification of one of them that appears to be satisfactory. The paper concludes with a brief description of some of the residual problems.

I

The first puzzle was brought to my attention by Barbara Partee. In order to present it, we should review how Montague treats tense in his fragments. In the fragments presented in Montague (1970b) and in Montague (1970c), Montague treats only the simple present tense. So these fragments contain only unadorned sentences such as **John walks** and **Mary eats a fish**. However, the fragment presented in PTQ includes along with the simple present tense, the present perfect and the simple future tenses. This fragment includes sentences such as **John walks**, **John has walked**, and **John will walk**. The progressive tenses are conspicuously absent in these fragments. The fragments do not treat sentences such as **John is walking**, **John has been walking**, and **John will be walking**. Montague was well aware that the progressive tenses seemed to require a different treatment.

In PTQ the truth-value of a sentence (under an interpretation) is considered relative to a point of reference which is an ordered pair consisting of a possible world and a moment of time. The set of moments of time is linearly ordered. For our purposes, we can drop the possible world coordinate. Montague

gives the standard analyses of the present perfect and the simple future. These analyses are indicated by the following truth conditions:

John has walked is true at moment of time t
if and only if there exists a moment of time t'
such that $t' < t$ and **John walks** is true at t' .

John will walk is true at moment of time t
if and only if there exists a moment of time t'
such that $t < t'$ and **John walks** is true at t' .

What is important to notice here is that these analyses of the present perfect and the simple future depend on the notion of a sentence in the simple present having a truth-value at a moment of time.

When starting to work with a Montague fragment, one of the first things one begins to wonder about is how we use the simple present tense in ordinary English. Consider the sentence **John walks**. It seems that we can use this sentence to make a variety of statements. For example, we can assert that John habitually walks, that he frequently walks, or that he regularly walks. I am not sure how many readings of this sort are to be distinguished. Notice that these readings can be true at a moment and yet John is not walking at that moment. Let us call such readings of the sentence **John walks** *non-reportive* readings⁽¹⁾. Such readings are to be distinguished from the *reportive* reading which asserts that John performs the act of walking at the present moment. It seems that we often have occasion to use a sentence in the simple present like **John loves Mary** in the reportive sense. However it seems that we usually use a sentence like **John walks** in a nonrepor-

(1) David Kaplan thinks that there is only one nonreportive reading of the simple present tense and believes that it is none of the readings that would be expressed by using an adverb of frequency. I am not sure he is right about this. In any case, the points I wish to make do not depend on this issue.

tive sense and that we seldom use such sentences in this reportive sense.

Which sense of the simple present does Montague intend to be treating in his fragments? This is never made clear in his papers. Further I do not think that one can confidently infer from the nature of the fragments which sense, if any, is intended. You might think that it is evident that he is treating the reportive sense of the simple present since it is this tense which underlies his analyses of the present perfect and the simple future. However both these tenses allow for nonreportive readings as well. **John has walked** can mean that John has occasionally walked, John has usually walked, and so forth. For various reasons, I am inclined to believe that Montague does intend to be treating the reportive sense of the simple present. Let me give just one reason. In PTQ, Montague considers sentence (a) to have only one reading—a reading that entails that there is at least one fish.

(a) **John eats a fish**

However, if we give (a) a nonreportive sense, intuitively it has a reading that does not entail that there is at least one fish. For example, (b) has a reading that does not entail the existence of fish.

(b) **John occasionally eats a fish**

It could be true at a certain time that John occasionally eats a fish but false at that time that there is a fish. Evidence such as this leads me to believe that Montague intends to be treating the reportive sense of the simple present.

Some sentences in the simple present seem to wear the reportive sense more comfortably than others. We can easily imagine that we might have occasions to use the following sentences in the reportive sense to make statements.

John believes that Mary loves him
John walks

However it seems much less likely that we would have occasion to use sentence (c) in the reportive sense.

(c) **John builds a house**

Why is this? When we use the simple present in the reportive sense, we psychologically perceive the described event as taking place in its entirety at the moment of speech. It seems unlikely that we would have occasion to use (c) in the reportive sense since this would be an occasion where we perceive John to build a house at an instant. Of course, the usual situation when one encounters an event of house-building is that it is extended through time and overlaps the present moment. In such cases we use the present progressive, **John is building a house**.

A familiar situation in which the reportive simple present is used is sports reporting, **Jones throws the ball to Smith**. Again this tense is being used because the events are being viewed as almost instantaneous and as occurring at the moment of speech.

The so-called «historical present» tense seems to be related to the reportive simple present. This tense is used to describe past events as if they are happening at the moment of utterance. For example, if we are reviewing John's life history, we might use (c) in the historic present tense. Here we are, so to speak, «speeding up the past action» and describing the past event of John's building a house as if it is almost instantaneous and occurring at the moment of speech⁽²⁾.

I hope I have provided enough background in order to effectively present the first puzzle. Montague treats a sentence like **John has built a house** as indicated in the following truth condition:

John has built a house is true at moment of time t if and

(2) After struggling to achieve this understanding of the simple present tense in the reportive sense, and the historical present tense, I was pleased to see that Leech (1969, pp. 139-140) gives essentially the same explanation.

only if there exists a moment of time t' such that $t' < t$ and **John builds a house** is true at t' .

After thinking about the way we use the simple present, and because I believe that Montague intends to be treating the reportive sense of that tense, his truth condition for **John has built a house** in the reportive sense turns out to be that there exists a past moment at which John instantaneously builds a house. Of course, it is logically possible that someone build a house at an instant. But an adequate analysis of the present perfect should allow for the more normal kind of house-building. Let me state the first puzzle relative to the sentence **John has built a house**. How can we reflect in the analysis of the present perfect in the reportive sense the intuition that the truth condition for **John has built a house** is that there exists some past interval of time, possibly a moment of time, during which John is building a house and eventually completes it?

Incidentally, it seems implausible to think that **John builds a house** in the reportive sense is true at the moment that John completes the house, that is, at the moment when he drives in the last nail. For if someone says that John built a house last month, no one asks on which day and at what time he did it.

The second puzzle concerns an analysis of the present progressive tense in the reportive sense that Montague presents in his paper (1970a, p. 125). His remarks suggest that the analysis might be due to some extent to Dana Scott. In fact the analysis does make a brief appearance in Scott (1970, p. 160). Let us represent time by the set of real numbers T . I indicate the analysis by giving truth condition (1) for the very sentence that Montague chose to illustrate his analysis.

- (1) **Jones is leaving** is true at moment of time t if and only if there exists an open interval of moments of time, say I where $I \subseteq T$, such that t is a member of I and for all times t' in I , **Jones leaves** is true at t' .

The idea here is that a sentence in the present progressive in the reportive sense is true at a moment t , if there exists a

neighborhood about t such that the related sentence in the simple present tense in the reportive sense is true at all times in the neighborhood. This analysis, as I said, appears in Montague (1970a). It is clear in that paper that Montague would give the same analysis of the present perfect tense that he gives in PTQ, Montague (1970a, p. 125). Thus along with (1) we have truth condition (2).

- (2) **Jones has left** is true at moment of time t
 if and only if there exists a moment of time t'
 such that $t' < t$ and **Jones leaves** is true at t' .

Now given these truth conditions, **Jones is leaving** entails **Jones has left**. For if **Jones is leaving** is true at moment of time t , there is a neighborhood about t such that for all times in the neighborhood **Jones leaves** is true at those times. But the neighborhood must contain a time earlier than t . Therefore **Jones has left** is true at t . Intuitively **Jones is leaving** does not entail **Jones has left**. It could be true that Jones is leaving but false that he has left. There are verb phrases where the present progressive intuitively does entail the present perfect. For example, **Jones is walking** intuitively entails **Jones has walked**. What accounts for this difference?

There is a well-known classification of intransitive verb phrases in the philosophical literature which distinguishes stative verb phrases, activity verb phrases and performance verb phrases⁽³⁾. I am not entirely happy with this terminology but I am using it because it is familiar⁽⁴⁾. *Stative* verb phrases

⁽³⁾ Aristotle appears to have been the first to notice the difference between an activity and a performance: *Metaphysics*, 1048b 18-35; and *Nicomachean Ethics*, 1174a 14 - 1174b 7. Gilbert Ryle, in his classic (1949, chapter 5, section 5) called attention to Aristotle's observation and triggered a string of discussions in the philosophical literature: Ackrill (1965), Kenny (1963, chapter 8), Lemmon (1968), Penner (1970), Potts (1965), and Vendler (1967). Vendler distinguishes four different kinds of verb phrases, but I believe that there are only three. I am especially grateful to John Giuliano with whom I have spent many hours discussing this topic.

⁽⁴⁾ The terminology comes from Kenny (1963). It is misleading because it suggests that we are concerned only with verb phrases that describe

are used to ascribe states of individuals. Some examples are **be happy**, **love Mary**, and **believe that Mary loves John**. They characteristically do not take the progressive tenses. For example, notice that the following is ungrammatical ⁽⁵⁾.

***Bill is believing that Mary loves John**

Activity verb phrases do take the progressive tenses. Some examples are **walk** and **push a cart**. One characteristic of these verb phrases is that intuitively the present progressive form entails the present perfect. For example, **John is walking** entails **John has walked** and **John is pushing a cart** entails **John has pushed a cart**. *Performance* verb phrases also take the progressive tenses. Some examples are **leave** and **build a house**. However they are distinguished from the activity verb phrases in that intuitively the present progressive form does not entail the present perfect. **Jones is leaving** does not entail **Jones has left** and **John is building a house** does not entail **John has built a house**. This is because a performance verb phrase describes an act or event that involves a completion whereas an activity verb phrase does not. Returning to the Montague-Scott analysis of the present progressive tense, we see that the analysis seems adequate for activity verb phrases but inadequate for performance verb phrases.

The second puzzle is the following. How do we analyze the present progressive tense for performance verb phrases? It would be nice if we could give a uniform analysis of this tense for both activity and performance verb phrases. Of course, in addition, the two kinds of verb phrases would have to be distinguished in certain ways with respect to entailments.

Now that we have our two puzzles before us, I will attempt to account for them by using a suggestion of Barbara Partee's. Let us continue to represent time by the set of real

intentional actions—actions of conscious beings. However, **move** and **disintegrate**, an activity verb phrase and a performance verb phrase respectively, can be used to describe nonintentional events.

⁽⁵⁾ As usual, the asterisk indicates ungrammaticality.

numbers. But let us change the notion of a point of reference from that of an ordered pair consisting of a possible world and a moment of time to that of an ordered pair consisting of a possible world and an interval of time. We take an interval of time to be a set of moments of time ⁽⁶⁾. So certain intervals, namely the one-membered sets, correspond to moments of time. In short, the suggestion is to consider the truth-value of a sentence relative to an interval of time and not just a moment ^(7,8).

This notion enables us to account for the first puzzle. We give (3) as the truth condition for **John has built a house** in the reportive sense.

- (3) **John has built a house** is true at interval of time I if and only if I is a moment of time, and there exists an interval of time I'

⁽⁶⁾ It might be desirable to allow only certain kinds of sets of moments of time to be intervals. For example, one might allow only sets with an upper and lower bound, sets with endpoints, connected sets, sets having combinations of these properties, etc.

⁽⁷⁾ I find this notion of a sentence having a truth-value relative to an interval prefigured in Montague (1969, p. 150) and in Lemmon (1968, p. 100). Montague (1969) analyzes an event as a property of moments of time—a function from possible worlds to sets of 1-place sequences of moments of time. An experience is analyzed as a function from possible worlds to sets of 2-place sequences of persons and moments of time. The latter is a minor variation of his analysis of the intension of an intransitive verb phrase in PTQ—a function from ordered pairs of possible worlds and moments of time to sets of individuals (actually individual concepts but that is irrelevant here). Montague states in Montague (1969) that his analysis of events is adequate for *instantaneous generic events*. In order to treat *protracted generic events*, such events should be identified with properties of intervals, rather than moments, of time (or more generally with properties of unions of intervals of time). From this one can extrapolate a more general analysis of the intension of an intransitive verb phrase—a function from ordered pairs of possible worlds and intervals of time (or more generally, unions of intervals of time) to sets of individuals. On this line, a point of reference is an ordered pair of a possible world and an interval of time. Accordingly we would now consider the notion of a sentence being true (under an interpretation) relative to a possible world and an interval of time.

(possibly a moment) such that $I' < I$, and John is in the extension of **build a house** at I' .

The truth condition requires that there exist a past interval of time at which John is in the extension of **build a house**. The intuition motivating this analysis is that if John is in the extension of **build a house** at an interval I , then the event of John's building a house is regarded as starting at the beginning of I , taking place during I , and finishing at the end of I . This reflects our intuition that the truth condition should involve some past interval of time during which John is building a house and eventually completes it.

We now turn to the second puzzle. We give (4) as the truth condition for **Jones is leaving**.

- (4) **Jones is leaving** is true at interval of time I if and only if I is a moment of time, and there exists an interval of time I' such that I is a member of I' but I is not an endpoint for I' , and Jones is in the extension of **leave** at I' .

The idea here is that a sentence in the present progressive in the reportive sense is true at a moment t if t is in the middle of an interval of time at which Jones is in the extension of

(⁸) I have in mind a framework similar to that in PTQ where a translation relation holds between analysis trees for English sentences and formulas of intensional logic. The proposal is that we consider the more general notion of a formula of intensional logic being true with respect to an interval of time. However translations corresponding to analysis trees for English sentences will be designed in such a way that they can be true only with respect to moments of time. Intervals of time will just play a role in the truth conditions for such translations.

This is a simple but misleading way of putting what I really have in mind. More precisely, I believe that any simple present tense sentence (and possibly sentences in the other tenses) expresses a proposition (a function from world-times to truth values) that is true only at world-times where the sentence is true at the world in question and the now of the context of utterance. For an elaboration of this cryptic remark, see Bennett (1976, section 12).

leave. In other words, **Jones is leaving** is true at a moment of time t if t is in the middle of an event of Jones' leaving ⁽⁹⁾. On this analysis, **Jones is leaving** does not entail **Jones has left** since if **Jones is leaving** is true at a moment t , there is no guarantee that there exists an interval of time earlier than t at which Jones is in the extension of **leave**.

This takes care of performance verb phrases. How about activity verb phrases? The truth condition for **Jones is walking** exactly parallels truth condition ⁽⁹⁾ for **Jones is leaving**. However, we still have to accommodate our intuition that **Jones is walking** entails **Jones has walked**. This can be done by placing a special condition on activity verb phrases. The condition is that if an individual is in the extension of an activity verb phrase at an interval I , then it is in the extension of the verb phrase at every subinterval of I including every moment of time included in I . For example, if Jones is in the extension of **walk** at the interval yesterday, then Jones is in the extension of **walk** at every subinterval of yesterday including every moment of time included in yesterday. Given this special condition for activity verb phrases, **Jones is walking** entails **Jones has walked**. For if **Jones is walking** is true at a moment of time t , then there exists an interval of time I about t at which Jones is in the extension of **walk**. But interval I must include a time t' earlier than t . Since **walk** is an activity verb phrase, Jones must be in the extension of **walk** at t' . Therefore **Jones has walked** is true at t .

Stative verb phrases characteristically do not take the pro-

⁽⁹⁾ The analysis of the present progressive tense might be objected to as follows. For any moment of time t , usually there will exist an interval I about t such that Jones is in the extension of **not leave** at I . Therefore, considering **Jones is not leaving** to have a truth condition parallel to (4), **Jones is not leaving** is true at t . The analysis cannot be correct, it is argued, since whenever **Jones is leaving** is true at a moment of time, usually **Jones is not leaving** will also be true at that moment of time.

I do not accept this objection since I do not think that **Jones is not leaving** has a truth condition parallel to (4). I regard **Jones is not leaving** as having only one reading, the reading contradictory to the reading of **Jones is leaving**.

gressive tenses. This feature can be reflected semantically by requiring that an individual can be in the extension of a stative verb phrase, such as **believe that Mary walks**, only with respect to moments of time.

The solution I have been sketching is defective. Consider sentence (d).

(d) **John was building a house at midnight on Tuesday**

On our analysis, (d) is true at the present moment if there exists some interval of time I about midnight on Tuesday such that John is in the extension of **build a house** at I. The intuition that motivates our analysis is that if John is in the extension of **build a house** at I, then John starts to build at the beginning of I, he is building throughout I, and he finishes building a house by the end of I. So our analysis of (d) is such that, in some sense, (d) implies that John completes the house. But then how can we explain a sentence like (e) ?

(e) **John was building a house when he died
at midnight on Tuesday**

It seems that if (e) is true, then the sentence **John is building a house** is true either at the moment that John dies or shortly before. This indicates that **John is building a house** has a reading that does not imply the completion of a house in any sense. The reading is almost paraphrased by the sentence **John is working to build a house**. Such a reading will require an analysis of the present progressive other than the one I have considered ⁽¹⁰⁾. In fact, the existence of this noncomple-

⁽¹⁰⁾ As mentioned above, the noncompletion reading of **John is building a house** is almost paraphrased by **John is working to build a house**. Notice that the verb phrase **work to build a house** involves the higher-order verb **work** which provides an intensional context. Thus the «paraphrase» allows for a reading that does not imply the existence of a house. The noncompletion reading of **John is building a house** shares this feature. However the «paraphrase» is not exact because **build a house** is a performance verb phrase whereas **work to build a house** is an activity verb phrase. In part II I make a suggestion about how to analyze the noncompletion reading of **John is building a house**.

tion reading leads me to believe that a sentence like **John is building a house** has no completion reading whatsoever. I doubt that we use a sentence like **John is building a house** to make statements that imply that he will finish the house ⁽¹¹⁾. Is there any way to modify the interval of time approach so that it accommodates these intuitions and successfully solves the two puzzles?

II

David Dowty has proposed such a solution, Dowty (1977). I will give only a very rough account of his proposal; for more details, the interested reader should see his paper. The leading idea is to employ branching possible worlds. A sentence like **John is building a house** is true at a time *t* in the actual world if there exists some possible world *w* and some interval of time *I* such that *t* is included in *I* but is not an endpoint, *w* is just like the actual world up to time *t*, and John is in the extension of **build a house** at *I* in possible world *w*. This allows for the possibility that **John is building a house** is true in the actual world even though John will never complete the house in that world; the completion takes place in a possible world that branches away from the actual world at the moment of utterance ⁽¹²⁾.

I doubt that Dowty's solution works. I find it implausible that the truth condition for a sentence like **John is building a house** involves a possible world that *might* differ from the actual one. It seems to me that the sentence strictly asserts something about the actual world; it reports an actual, on-going activity. My reservation can be stated more decisively: Dowty's analysis fails to account for the fact that **John is**

⁽¹¹⁾ Dahl (1973, pp. 21-22) considers our analysis of the present progressive tense and rejects it because, in essence, he believes that a sentence like **John is building a house** has only a noncompletion reading. I now believe that this criticism is correct.

⁽¹²⁾ Østen Dahl proposes an analysis that is similar to Dowty's, Dahl (1973, p. 22).

walking implies both **John will be walking** and **John will walk**. Dowty is well aware that his analysis fails to yield these entailments, cf. (1977, pp. 59-60). He is convinced that they should not follow by considering examples in the past progressive tense: **John was walking when he exploded** ⁽¹³⁾. But let us consider the present progressive tense. What is the truth condition for (f) ?

(f) **John is walking**

Intuitively, (f) is true at a moment of time *t* if there exists some *ongoing* activity of walking that occurs both before and *after* the moment *t*. (f) asserts that some of the activity will occur in the future; not in the future of some possible world, but in the future of the *actual* world. Suppose John was walking and then he ceased to walk at time *t* — stopped the activity altogether. Could (f) be true at time *t* ? My intuition is that (f) is false at *t*. What is true at *t*, in such a case, is **John ceases to walk** or **John stops walking**.

My own view is that the fact that **John is building a house** has a reading that does not imply the existence of a house should be explained by analyzing **build** as an intensional verb. More precisely, I propose to analyze the performance verb phrase **build a house** as **build something to be a house** ⁽¹⁴⁾. This allows for **a house** to have narrow scope with respect to an intensional context, and this explains why **John is building a house**, on one reading, does not imply that there is, or will be, a house. (I will elaborate on this proposal in part III.) There are several verbs like **build** that allow for such nonreferential readings: **draw, paint, compose, write, make**. Such verbs form

⁽¹³⁾ My intuition is that if **when** is read as meaning «at the time that», then this sentence must be false. When we take it to be true, we are reading **when** as meaning «just before» or «shortly before».

⁽¹⁴⁾ This paraphrase is somewhat awkward. A more natural one might be **build something into a house**, cf. **make something into a house**. However I prefer the former since it is more transparent with respect to its logical form.

a special class which I will call *verbs of creation* ^(15,16). But this distinction still leaves us with the problem that Dowty tries to solve: accounting for the fact that **John is walking to a house** does not imply, in effect, **John will have walked to a house** ⁽¹⁷⁾. I now believe that this problem can be handled by some minor adjustments to the first proposal.

III

The following modification was suggested to me by Glen Helman. The leading idea is to distinguish in some way the intervals of time that represent occurrences of performances from the intervals of time that represent occurrences of activities. Let us say that activities are represented by *open* intervals (no endpoints) and that performances are represented *closed* intervals (two endpoints). Both performance verb phrases and activity verb phrases can be true of both open and

⁽¹⁵⁾ Now that we have discovered the verbs of creation, we must not blind ourselves to the *verbs of destruction*.

⁽¹⁶⁾ Why give verbs of creation such complicated paraphrases? Why not regard them as intensional verbs like *seek*, cf. PTQ? The reason is that such paraphrases can explain why arguments like the following are invalid:

this ring is this gold
John made this ring

John made this gold

This failure is usually explained by reading the *is* in the first premise as meaning «is made of». But I believe that it is simply the *is* of identity. The invalidity results from the fact that *make* is a verb of creation. The argument actually has the following form:

this ring is this gold
John made this ring to be a ring

John made this gold to be gold

It is clear why the conclusion does not follow from the premises. What does follow is:

John made this gold to be a ring

⁽¹⁷⁾ The performance verb phrase *walk to a house* involves a *verb of motion*. See Bennett (1976, section 15) for some discussion of this type of verb.

closed intervals⁽¹⁸⁾. (It will be explained below how the two kinds of verb phrases are distinguished.) We give (5) as the truth condition for **Jones has left**.

- (5) **Jones has left** is true at interval of time I if and only if I is a moment of time, and there exists an interval of time I' (possibly a moment) such that I' is a closed interval, $I' < I$, and Jones is in the extension of **leave** at I' .

The difference between this proposal and (3) is the requirement that I' be a closed interval. This technical device reflects the intuition that the present perfect tense always describes a performance; the perfect aspect indicates a completion. (6) is the truth condition for **Jones is leaving**.

- (6) **Jones is leaving** is true at interval of time I if and only if I is a moment of time, and there exists an interval of time I' such that I' is an open interval, I is a member of I' and Jones is in the extension of **leave** at I' .

Here the new idea is the additional requirement that I' be an open interval. This reflects the intuition that the present progressive always describes an activity. Although (5) and (6) involve the performance verb phrase **leave**, it is intended that the same analyses would be given if we shifted to an activity verb phrase.

Clearly this proposal solves the first puzzle. However it also solves the second. **Jones is leaving** neither implies **Jones has left** nor implies, in effect, **Jones will have left**, since there is no guarantee that Jones is in the extension of **leave** with respect to a *closed* interval. In other words, the truth of **Jones is leaving** gives no guarantee that a performance of leaving has, or will have, taken place.

⁽¹⁸⁾ The expression «verb phrase is true of an interval of time» is a short way of saying that there exists an individual that is in the extension of the verb phrase with respect to the interval of time.

Activity verb phrases are distinguished from performance verb phrases by requiring that the former satisfy the following condition: if an activity verb phrase is true of an interval, then it is true of every *closed* subinterval⁽¹⁹⁾. The intention here is, roughly, that every part of an activity is a performance. We do not impose this condition on performance verb phrases. This requirement explains why **Jones is walking** implies **Jones has walked**. Suppose **Jones is walking** is true at *I* which is a moment of time. Then there exists an open interval of time *I'* such that *I* is a member of *I'* and Jones is in the extension of **walk** at *I'*. But given these conditions and the fact that time is taken to be the real numbers, there exists a closed interval of time *I''* that is a subinterval of *I'* such that $I'' < I$. Given the condition imposed on activity verb phrases, Jones is in the extension of **walk** at *I''*. From this it follows that **Jones has walked** is true at *I*.

It is necessary to impose the following condition on both activity verb phrases and performance verb phrases alike: if a verb phrase is true of an interval, then it is true of every *open* subinterval. Intuitively every part of either an activity or a performance is an activity. However, it is not so easy to give simple examples of entailments that depend on this condition. I will provide the following examples without detailed discussion. We need the open subinterval requirement on performance verb phrases to ensure that **Jones walked to the store in ten minutes yesterday** implies **Jones was walking to the store yesterday**. (The phrase **in ten minutes** is serving to exclude the possibility that the performance occurred in an instant.) The open subinterval requirement is needed for activity verb phrases so that **Jones walked for ten minutes yesterday** implies **Jones was walking yesterday**. (The phrase **for ten minutes** is serving to exclude the possibility that the performance occurred in an instant)⁽²⁰⁾.

⁽¹⁹⁾ This requirement, and the others mentioned below, can be imposed by a meaning postulate.

⁽²⁰⁾ Why not give (4) and (5) as the analyses of the present progressive and the present perfect, especially since the open subinterval requirement

Let me mention some other conditions that must be imposed. Intuitively **John is walking to a house** implies **there is a house**. This can be guaranteed by requiring that if an individual is in the extension of **house** with respect to an interval of time *I*, then it is in the extension of **house** with respect to very subinterval of *I*, including every moment in *I*. (I am assuming that we already have ensured that **walk to** is extensional in object position, cf. Bennett (1976, section 19).)

In part II I explained how **John is building a house** might not imply that a house exists or will exist. The performance verb phrase **build a house** is analyzed as **build something to be a house**. This allows for **a house** to have narrow scope with respect to an intensional context. In effect, I am analyzing **John is building a house** as **John is building something to be a house**. The latter implies that there is something but not that there is a house. However, **John built a house last year** should imply **a house existed last year**. But how does this follow if the former sentence is analyzed as **John built something to be a house last year**? We impose the condition that if John is in the extension of **build something to be a house** at a closed interval *I*, then something is in the extension of **be a house** at the final endpoint of *I*. A similar condition should be imposed on the performance verb phrase **walk to a house**: if Tom is in the extension of **walk to Monticello** at a closed interval *I*, then **Tom is at Monticello** is true at the final endpoint of *I* ⁽²¹⁾.

then appears to be superfluous? I have no strong objections to this approach, but I do not favor it. First, it seems right to analyze the present progressive so that it depends on the existence of an activity. Second, intuitively the open subinterval requirement is correct for performance verb phrases; any performance other than a momentary one involves some activity. Suppose we take (4) and (5) as our analyses. Is it necessary to impose the open subinterval requirement? It is difficult to find an intuitive entailment that depends on it. The best example I can think of is **John built a boat in one month last year** implying **John built a boat for ten days last year**. We must read the second sentence as describing an activity that lasted for ten days. But it is controversial whether the sentence has this reading.

⁽²¹⁾ Emmon Bach has argued that my approach cannot explain why **John**

IV

So far we have considered just a few problems which are central to the task of formalizing tense and aspect in English. There remains a wide range of related issues that need to be considered before an adequate formalization can be realized. A topic that surprisingly has received little attention from tense logicians is a class of verbs that includes some inchoatives, verbs such as **begin**, **resume**, **continue**, and **finish**. These verbs have definite logical structure. For example, **John walked to Chicago last year** implies **John began to walk to Chicago last year**, but not vice versa.

Another important area of investigation is that of temporal adverbial phrases. I distinguish at least four important categories: frame adverbial phrases, durative adverbial phrases, subordinate clauses, and adverbs of number and frequency. A frame adverbial phrase refers to an interval of time within which the described event is asserted to have taken place. Such adverbial phrases are often indexical in character; **today** and **next year** are examples. A durative adverbial phrase specifies the length of time of the described event. Some examples are **for three days** and **from two to three o'clock**. A temporal subordinate clause serves to locate in time a described event by relating it in time to another described event. Such clauses are headed by expressions such as **while**, **when**, **before**, **after**, **since**, and **until**. These three kinds of adverbial phrases obey various restrictions in the way that they interact with the different tenses and kinds of verb phrases. In fact it is essen-

is finding a unicorn implies **John is not finished yet**. This is a puzzling challenge, and I am not sure what to make of it. The problem is that I do not know how to analyze the second sentence. Notice that **John is finding a unicorn** might not imply **John has not finished finding a unicorn**. The closest I can come to making sense of what is going on is to view the two sentences as being in a discourse.

John is finding a unicorn.

He is not finished doing it yet.

The **it** in the second sentence is referring to the action described by the first sentence. This is a case of anaphora, a phenomenon about which I have little understanding.

tial to understand the role of these temporal adverbials if one is to gain a proper understanding of the tenses themselves.

Let me elaborate on this last point by taking a closer look at the present perfect and the simple past tense. The analysis of the present perfect sketched above is inadequate. It does not reflect the fact that whenever we use a sentence in the present perfect, there is always a reference to an interval of time that includes the present moment, or the moment of utterance, as well as past moments. The event described is asserted to take place within this interval. Some evidence for this view is that sentences in the present perfect can take temporal adverbial phrases that refer to intervals of this sort but cannot take adverbial phrases that refer to other kinds of intervals.

John has just left

John has walked today

John has eaten a fish since March

***John has left two days ago**

***John has walked yesterday**

***John has eaten a fish last year**

The temporal adverbial phrases in the grammatical sentences refer to intervals of time that include the present moment whereas those in the ungrammatical sentences do not. A central difference between the present perfect tense and the simple past tense is that the latter can take temporal adverbials such as those in the ungrammatical sentences above. We often use sentences in the present perfect and the simple past that do not contain a temporal adverbial phrase at all. I believe that in all such cases there is always an implicit reference to an interval of time of the appropriate sort which is determinable from the previous discourse or the extralinguistic features of the context of utterance. An adequate analysis of the tenses will have to account for this feature.

Adverbs of number and frequency indicate the number of times that a generic event occurs or its frequency. All such adverbs correspond to quantifiers, usually ones in the plural:

twice, two; seldom, few; occasionally, a few; frequently, many; usually, most. The plural quantifiers are clearly involved in the analysis of these adverbs ⁽²²⁾. However Lewis (1975) raises some apparent difficulties for the obvious treatment ⁽²³⁾. Another important problem is to investigate the relationship between the nonreportive reading(s) of the simple present tense, its customary reading, and the various readings involving adverbs of frequency. Does **John walks** have as one of its readings **John frequently walks**?

A very pressing problem is that of the sequence of tenses. This is not merely a syntactic problem, but as Gabbay (1974)

⁽²²⁾ See Bennett (1974, section 4.1) for some discussion of the logic of the plural quantifiers.

⁽²³⁾ I have in mind two possible difficulties. Lewis (1975, p. 4, fn. 1) suggests the following problem. Suppose Miles the war hero is wounded by two bullets at exactly the same moment or interval of time. Then (a), it is argued, should be true the next day.

(a) **Miles was wounded by a bullet twice yesterday**

But on the approach I have been sketching, (a) is true if Miles is in the extension of **be wounded by a bullet** with respect to two intervals of time within yesterday. However, given the situation described, this truth condition is not met since both bullets entered Miles at exactly the same moment or interval. The example suggests that analyzing adverbs of number and frequency as counting intervals of time is inadequate, and that they should be counting occurrences of generic events which might be cotemporaneous. But are there two occurrences of the generic event *Miles' being wounded by a bullet* in the situation described? It might be that it is impossible for there to be two occurrences of a generic event that are contemporaneous with one another. (In effect, I am defending Montague's analysis of events in Montague (1969, pp. 149-150).) If this is so, (a) should be false in the situation described. There is a sentence that fully describes the situation which is true on my approach:

Miles was wounded by two bullets yesterday

The other problem is that adverbs of number and frequency are used in cases where the entities being counted are not even arrayed in time. Lewis' example is:

a quadratic equation usually has two different solutions

I am inclined to give the obvious analysis to the adverbs and to regard such examples as extended uses of the language. But David Lewis thinks otherwise, Lewis (1975, p. 5).

has emphasized, a semantic one as well ⁽²⁴⁾. How do we generate a sentence like **yesterday John believed that Mary was amused**? The problem is that the tense of the complement sentence depends on the tense of the higher verb. The sentence asserts that at some time yesterday John believed that Mary was amused at that time. Somehow the operator corresponding to **yesterday** «binds» the «tense variable» in both the higher verb and the verb of the complement sentence. This suggests a need for a treatment similar to that sketched in Partee (1973).

I firmly believe that these questions lie at the heart of the problem of giving a semantics for natural language. Any progress in this area will reveal something about the metaphysical framework that underlies language. A successful treatment will suggest how we regard the nature of time and such metaphysical entities as states, acts, actions, and events ⁽²⁵⁾. Such progress would be welcomed by linguists, logicians, philosophers, and psychologists alike ⁽²⁶⁾. In my own field, on several occasions, I have found that a philosophical discussion was vitiated because insufficient attention had been paid to matters of tense and aspect ⁽²⁷⁾. This can lead to an unnatural semantics and/or a bizarre ontology ⁽²⁸⁾.

⁽²⁴⁾ However, I do not see the problem quite like Gabbay. He seems to have missed the importance of the temporal adverbials.

⁽²⁵⁾ I do not suppose that the distinction between generic acts and actions is very clear in English. But it appears that the distinction between generic performances and activities is a close approximation. Our semantics analyzes the latter entities as properties of individuals: functions from ordered pairs of possible worlds and intervals of time to sets of possible individuals. Generic events, from this point of view, are analyzed as propositions.

⁽²⁶⁾ Miller and Johnson-Laird (1976) discuss at length the interest that such investigations have for psychology.

⁽²⁷⁾ Peter Geach makes a mistake of this sort, Geach (1969, p. 292). He gives the following argument to show that **pick out** is an intensional verb. He points out that (a) and (b) do not jointly entail (c); that is, Leibniz' Law fails.

- (a) **procedure P picks out the coldest state**
- (b) **the coldest state is the least populous state**
- (c) **procedure P picks out the least populous state**

At first sight this is very plausible. Imagine that procedure P always runs

There are important areas of syntax and semantics that cannot be studied independently of tense and aspect. There is the problem of «bare» plurals, as in **Mary flies kites**; and the problem of generic readings, as in **the lion has a tail**. Modals and the transformational process of nominalization, which creates gerundive expressions, can be understood only when one is enlightened about tense and aspect. We might be able to solve these problems if we first build a proper foundation.

through temperature records of the states and then selects the coldest state on that basis. Thus (a) is true. (b) is true because it so happens that at this time Alaska, which is the coldest state, is also the least populous state. But (c) is false. Although procedure P picks out the least populous state at *this time*, it might not always do so because procedure P only considers temperature records and not population statistics. It is possible that at some time in the future the coldest state might not be the least populous state.

Geach's mistake is that he considers only nonreportive readings of sentences (a) and (c). For example, he is reading (a) as asserting that procedure P *always* picks out the least populous state. Geach is right that on these nonreportive readings, (a) and (b) do not entail (c). However this does not show that **pick out** is an intensional verb. What is required is that given reportive readings, (a) and (b) do not entail (c). But this is not the case. Notice that by paralleling Geach's argument one can show that **eat** is an intensional verb. There are nonreportive readings for (d) and (f) such that (d) and (e) do not jointly entail (f).

- (d) **John eats the coldest fish**
- (e) **the coldest fish is the smallest fish**
- (f) **John eats the smallest fish**

Actually **pick out** is a paradigm of a nonintensional verb. There is no reportive reading of **John picked out a hat** that asserts that John picked out any hold hat, an arbitrary hat, cf. the nonreferential reading of **John sought a hat**.

(28) Possibly Anil Gupta is a case in point. He considers the following argument, Gupta (1977, pp. 30-32).

**National Airlines served at least two million passengers in 1975
every passenger is a person**

National Airlines served at least two million persons in 1975

He claims that the argument is invalid because the same person might be a passenger on more than one occasion. He suggests that «the principle of counting passengers is different from the principle of counting persons,» and he takes this as evidence for a nonstandard semantic treatment of com-

History and Acknowledgments

This paper is the result of several trials and errors. In Bennett (1971), I tried to preserve Montague's analysis of the present progressive but still account for the logical differences among the verb phrases. This first effort was criticized by Barbara Partee. She argued that the idea of a sentence being true at a point in time, which we had inherited from tense logic, was inadequate for analyzing natural language. She proposed that we consider a more general notion of a sentence being true at an interval of time. Up to that time, fall of 1971, I do not believe that anyone had explicitly made this suggestion; although the idea was prefigured in a few places in the litera-

mon nouns. Actually, the argument can be read in such a way that it is valid. (We must read the second premise as a statement that is *always* true.) Read the first premise as asserting that there was at least one occasion in 1975 when National Airlines served at least two million passengers. (The first premise is ambiguous; this is the reading where **at least two million passengers** has narrow scope relative to the temporal adverbial phrase.) The conclusion is given a similar reading. Of course this is not Gupta's reading of the argument. One way to express his reading in English is as follows:

**National Airlines served passengers at least two million times in 1975
passengers are always persons**

National Airlines served at least two million persons in 1975

The conclusion is read with **at least two million persons** having wide scope. (There is a problem here; some of the persons might no longer exist.) This argument is invalid for the reason that Gupta states. But we can see that this is so on a standard semantic treatment of common nouns. What is being counted in Gupta's situation is not the number of passengers but the number of times that a passenger was served. Does the first premise of Gupta's argument have the reading he claims for it? It seems that we do use the sentence intending that reading. But the existence of an uncontroversial way of expressing the reading suggests to me that the usage is a loose one, an extended use of the language that need not be accounted for by the semantics. (The first premise of the second argument does not capture the reading if two passengers are served at exactly the same moment or interval of time, cf. fn. 23.) But if the sentence does have the reading, it *will* be necessary to resort to a more complicated semantics. I doubt that it will be something like what Gupta proposes. An adequate treatment should emerge from a theory of tense and aspect.

ture. (By now, the use of intervals of time has some currency.) A year later I tried to carry through Partee's suggestions. We agreed to write a joint paper. This resulted in a first draft, Bennett and Partee (1972). It considered a wide range of phenomena in connection with tense and aspect, many of which are mentioned in part IV of the present paper. But the approach was informal; no fragment of English was presented. One reason for this was that we were not entirely clear about how to treat indexicals. Another was that we still did not have an adequate analysis of the present progressive tense—the problem discussed at the end of part I. Eventually we discontinued work on the project. Bennett (1973) was a short address in which I discussed our progress and the residual problems. This has become part I of this paper.

Since then there have been new developments. The linguist David Dowty adopted our interval idea and tried to solve the problem just mentioned, Dowty (1977). In part II I argue that his solution does not work. In the fall of 1975, I surveyed these problems in a seminar at the University of Pittsburgh. In reaction, Glen Helman proposed the solution that is sketched in part III. One of the main obstacles to giving a formal treatment of tense and aspect was an incomplete understanding of how to treat indexical expressions. But since then, I have worked out a treatment of demonstratives and indexicals in Montague's framework, Bennett (1976), a treatment based on some ideas of David Kaplan's. I have renewed hope that it will be possible to integrate these various elements and construct a fragment of English that includes all of the tenses. Necessarily this will involve a treatment of the various kinds of temporal adverbial phrases discussed in part IV.

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