CONTENTS

TENSE LOGIC AND TENSE AND ASPECT IN ENGLISH

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Abstract: Problems encountered in interpreting a standard tense logic with tense operators P and F as a model for natural language are discussed. A formal system is presented which eliminates some of these problems of interpretation.

Tense Logic and Natural Language.

Many advances in logic beyond the standard propositional calculus and 1st-order predicate calculus grew out of efforts to account for one or more of the several ways in which it seems insufficient to say of a grammatical sentence simply that it is either true or false. Tense logics have been developed in recent years by logicians and linguists who wished to reflect in their formal systems the property of natural language that the truth-value of a sentence may vary with time. We cannot say that the sentence "John is sick." is, in the real world, either true or false, but only that it is true or false relative to a given "historical moment", t. It is apparent that this dependency of truth-value on time affects the way we use language and must be reflected in any formal system which purports to adequately account for natural language phenomena. But while it is an advance to say that it is "S at t" rather than S that is true or false, deciding about the truth-value of "S at t" is, itself, as we shall see, not always an easy matter.

In assessing the "correctness" or "value" of a tense logic as a model for natural languages we can, in general, pose two kinds of questions. We may investigate, on the one hand, strictly formal properties of the system, such as its deductive completeness, its axiomatizability, the expressibility of certain of its symbols in terms of others and reductions to a minimal stock of primitive symbols, etc. On the other hand, we may evaluate the formal system on the basis of how well it "fits" natural language. That is to say, we may pose questions about what claims and predictions it makes about natural language and how closely those claims and predictions correspond to our intuitions about language. But in order to know what claims a system makes, we must first interpret the system by assigning meanings to its various elements. We have interpreted propositional calculus in this sense, for example, if we agree to let propositional variables represent grammatical English sentences and $\sim$, $\wedge$, $\vee$, and $\rightarrow$ "it is not the case that", "and", "or", and "if..., then..." respectively.

Logicians, understandably, tend to address questions of the first sort. In this paper, I wish to deal with certain questions of the second sort with respect to tense logics, although clearly the

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two sorts of questions are not unrelated. The increased interest in problems of tense and aspect on the part of linguists that has come about as a result of the advent of tense logic has produced a large number of recent articles in the area and a Symposium on Tense and Aspect at Brown University in January, 1978. I will ignore a great many problems, dealt with in various of these articles, which are clearly relevant to any completely adequate accounting of tense and aspect and concentrate principally on very basic questions about the relationship of progressives of "event propositions" to the simple past and future of such propositions on the one hand and to "state propositions" on the other, and on the nature of unmodified state propositions in the simple past and future tenses. I will investigate what implications the answers to these questions have for a formal system of tense and aspect.

The System PCK.

In order to provide a framework for this discussion and to illustrate the kinds of problems one has in trying to fit tense logics to natural language, I will exhibit a specific tense logic, which I will hereafter refer to as PCK. (The system presented is the propositional part of a system first developed by Prior and extended by Cocchairella as presented in (Kamp, 1968).) While there are a number of tense logics which differ from this logic in significant ways, PCK will serve our purposes of illustration well, since other tense logics do not differ from PCK in ways that are relevant to the issues I wish to discuss.

We define the system PCK as follows:

a) Vocabulary:

sentential constants: $q_0, q_1, \ldots$

sentential operators: 1-place: $\sim$, P, F
2-place: $\wedge$, $\vee$, $\rightarrow$, $\leftrightarrow$

b) Formulae:

(i) q_j is a formula

(ii) if ζ, Ψ are formulae, then $\sim\zeta$, $(\zeta \wedge \Psi)$, $(\zeta \vee \Psi)$, $(\zeta \rightarrow \Psi)$, $(\zeta \leftrightarrow \Psi)$, $P\zeta$ and $F\zeta$ are formulae.

c) Let M be a binary structure--i.e. a pair $\langle T, < \rangle$, where T is a nonempty set and $<$ is a binary relation on T. (We think of T as the set of moments of time and of $<$ as the earlier-later relation between moments.)

A possible interpretation for PCK relative to M is a pair <Q, R>, where Q is a sequence of subsets of T and R is the function with domain {~, ∧, ∨, →, ↔, P, F,} and range consisting of 1- and 2-place functions from 2^T into 2^T such that, if R(Ƶ) is written $R_Ƶ$,

(i) $R_{\sim}(J) = T - J$, for $J \subseteq T$.

(ii) $R_{\wedge}(J,K) = J \cap K$ for $J, K \subseteq T$.

(iii) $R_{\vee}(J,K) = J \cup K$, for $J, K \subseteq T$.

(iv) $R_{\rightarrow}(J,K) = (T-J) \cup K$. for $J, K \subseteq T$.

(v) $R_{\leftrightarrow}(J,K) = ((T - J \cup K) \cap ((T - K) \cup J)$, for $J, K \subseteq T$.

(vi) $R_P(J) = \{t \in T: \exists\, t' \in J$ such that $t' < t\}$, for $J \subseteq T$.

(vii) $R_F(J) = \{t \in T: \exists\, t' \in J$ such that $t < t'\}$, for $J \subseteq T$.

d) Truth:

For any possible interpretation $I = \langle Q,R \rangle$, formula Ψ of PCK and $t \in T$, "Ψ is true at t in I" is defined by the following two clauses:

(1) q_j is true at t in I iff $t \in Q_j$;

(2) if Ƶ is an n-place sentential operator of PCK and $\Psi_o, \ldots, \Psi_{n-1}$ are formulae of PCK, Ƶ$\Psi_o, \ldots, \Psi_{n-1}$ is true at t in I iff $t \in R_Ƶ(\{t' \in T$: Ψ_o is true at t' in $I\}, \ldots, \{t' \in T: \Psi_{n-1}$ is true at t' in $I\})$.

e) Validity:

A formula Ψ of PCK is M-valid iff for all possible interpretations I for PCK relative to M and all $t \in T$, Ψ is true at t in I. Two formulas Ψ and ζ are M-equivalent iff $\Psi \leftrightarrow \zeta$ is M-valid.

I will denote the set of formulae by Wff. Given a formula Ψ I will denote by $\Omega(\Psi)$ the set $\{t \in T: \Psi$ is true at $t\}$, and shall refer to $\Omega(\Psi)$ for any Ψ as the "truth interval" of Ψ. It should be noted that I am using "interval" in a sense distinct from its usual meaning, for we have said nothing yet to indicate that the sets $\Omega(\Psi)$ are other than arbitrary (possibly null) subsets of T. We have then

i) $\Omega(q_i) = Q_i$ for sentential constants q_i and

ii) $\Omega(ƶ\Psi_1, \ldots \Psi_n) = R_{ƶ}(\Omega(\Psi_1), \Omega(\Psi_2), \ldots, \Omega(\Psi_n))$

for formulae $\Psi_1, \ldots, \Psi_n$ and n-place sentential operator ƶ. I will take $\langle T, \langle\rangle$ to have the properties of the reals with "less than." It should further be noted that, given the definition of $R_{ƶ}$, we can give the truth conditions for $ƶ\Psi_1 \ldots \Psi_n$ at t as the condition on t in the definition of $R_{ƶ}$: i.e., $P(\Psi)$ is true at t if Ψ is true at some $t' < t$, $F(\Psi)$ is true at t if Ψ is true at some $t' > t$, etc.

Interpreting PCK

Let us interpret PCK by letting the q_i represent atomic, grammatical English sentences in the simple present tense, $P(q_i)$ and $F(q_i)$ the corresponding sentences in the simple past and future tenses, respectively, and by interpreting $\sim$, $\wedge$, $\vee$, and $\rightarrow$ in the usual way as representing "It is not the case that", etc. This interpretation is not as obvious as it may seem at first glance, for while it seems fairly safe to take P(q) and F(q) to represent sentences in the simple past and future, there are other possibilities for the q_i, namely that they represent atomic propositions in the present progressive or that they represent tenseless, atomic propositions. The question of the tense of propositions doesn't arise in interpreting non-tense logics, but in interpreting tense logic, where tense is precisely that aspect of language we are trying to deal with and where we define the truth intervals of P(q) and F(q) in terms of the truth interval of q, it is a question we must answer before we can claim to have interpreted the logic. None of the possible interpretations for the q_i is without problems. If we take q_i to have the simple present tense, we will have to decide whether, for example, given a historical moment t, the sentence "John writes his dissertation." is true or false relative to t, (or whether John is in the extension of "writes his dissertation" at t). If we answer that "John writes his dissertation" is true at precisely those t at which "John is writing his dissertation" is true, and that this is so for all q_i, we are claiming that they are truth functionally synonymous and have forfeited the chance of distinguishing the simple present and present progressive in our formal system. If we take the q_i to represent propositions in the present progressive, we have the problem of determining $\Omega(p)$ for those predicates which can't take the progressive tense (John knows Bill is a fink.). And taking the q_i to be tenseless propositions makes the task of making decisions about the truth value of q_i at t still more difficult. I have some intuition about whether or not it is true at the present moment that 'Bill is in a bad mood' or that 'John is writing his dissertation' or that "Sisley was English', and somewhat less about 'Bill writes his dissertation' or 'Bill was in a bad mood', but I have none at all about whether or not it is now true that 'Bill BE (tenseless) in a bad mood'.

Relative to whatever interpretation of PCK we settle on, the system makes a number of (not necessarily unrelated) claims about natural language. Three of these in particular we will investigate in some detail, namely:

a) The claim that there is associated with each atomic sentence, S, in the simple present (present progressive or tenseless) a subset $\Omega(S)$ of T such that S is true at t for all $t \in \Omega(S)$, and with each S of the form $\neq S_1, \ldots S_n$ a subset $\Omega(S)$ of T computable from $\Omega(S_1), \ldots, \Omega(S_n)$ by means of the "tense" $R_{\neq}$. We have already noted that the problem of finding $\Omega(q_i)$ for all q_i is problematical, regardless of how we interpret the q_i.

b) The claim that the truth-value constructions of natural language (those entities which are either true or false) are formula-time pairs, i.e. elements of Wff × T. It will be a major contention in what follows that a system in which this is not the case for all Ψ Wff more accurately reflects the way we use tense in natural language.

c) The claim that the "meanings" of the simple past and future tense in English are given by R_p and R_F, i.e., that past (S) is true at t if S is true at some $t' < t$ and that future (S) is true at t if S is true at some $t' > t$.

To assess the validity of these claims and to illustrate the difficulty in fitting PCK to natural language, consider a sentence such as S = "Leonardo PAINT the Mona Lisa". (I use PAINT here to indicate that the question of the tense of the verb is open.) We must decide what $\Omega(S)$ is to be. If we suppose that there are historical moments $a < b$ such that Leonardo started painting the Mona Lisa at a and finished at b, our instinct is to let $\Omega(S)$ be the interval (a,b). (I believe the device of using open and closed intervals for the truth intervals of activity and performance, respectively, is wrong. It is clearly only schematic.) But this set is clearly more nearly described by {t:"Leonardo is painting the Mona Lisa." is true at t} than {t:"Leonardo paints the Mona Lisa" is true at t}, if, indeed, the latter means anything at all. Moreover, if we let $\Omega(S)$ =(a,b), the definition of past tense given by R_p is clearly counter-intuitive. We would not want to say "Leonardo painted the Mona Lisa" is true at t for $a < t < b$, (for example, five minutes after a).

If S in the sentence "John WALK", the only possible candidate for $\Omega(S)$ would seem to be {t:"John is walking" is true at t}, in which case "John walked" is, according to our theory, true at t if "John is walking" is true at some $t' < t$. But I don't believe we would say, in English, "John walked" to indicate that at some prior moment John was walking.

For "stative" propositions, the interpretation of the q_i as representing sentences in the simple present and the definitions of past and future tense given by R_P and R_F fit somewhat better, but are still not without problems. If S is "John BE sick", only the simple present interpretation of the q_i is possible and $\Omega(S)$ must be $\{t$:"John is sick" is true at $t.\}$ But, if $t \in \Omega(S)$, it is at least strange to say "John was sick" at moment $t' > t$ if "John is sick" is true at t', as the system PCK predicts we can do. It is still stranger to say at moment t', "John was English" if "John is English" is true at t', even if there exists $t < t'$ such that "John is English" is true at t. But again, this would be predicted by PCK. The problem here obviously has to do with presuppositions of tensed expressions.

"Event" and "state" propositions

It is clear by now that the problems we are having interpreting PCK are connected with the fact that PCK fails to recognize different classes of propositions. It seems to me that the distinction between what are usually called "event propositions" and "state propositions", and further distinctions within each of those classes, are crucial to a proper treatment of tense and aspect, not only because tenses have different "meanings" depending on what kind of proposition they are attached to, but, more fundamentally, because state propositions (without temporal modification), unlike event propositions, are, in the simple past and future tenses, not (complete) propositions at all, in a sense we will make clear. To illustrate, note that while it makes sense to ask in isolation (where it is impossible that a context provides an understood "at t"), "Is it true or false that S?" if S is "Booth killed Lincoln" or "John is sick.", it does not make sense to ask the question if S is "John was sick." or "It was raining." One would respond to such questions not with "yes" or "no", but with something like "When do you mean?"

I am suggesting that sentences like "Booth killed Lincoln." differ from sentences like "John was sick." in the very fundamental sense that "Booth killed Lincoln." belongs to that set of things (propositions, formulae?) to which we assign truth values relative to time points while "John was sick." does not. I believe, instead, that it is pairs of the form (John was sick, t), where $t \in T$, that have truth values relative to historical moments, and that it is therefore pairs of the form ((John was sick, t_1), t_2) which are either true or false. I am claiming that "John was sick." is not something we would say, in English, to mean "there was a historical moment t' prior to the present moment at which the state of John's being sick obtained" (on which reading "Was John sick?" is synonymous with "Has John ever been sick?" For some speakers, the simple past with "ever" is synonymous to the present perfect in questions). Rather, we would only say something like "John was sick" in a context in which a t is provided, either explicitly in the sentence by means of a time adverbial or implicitly, by the context, and in which "John was sick" would be understood to mean "John was sick at t." (In contrast, a state proposition with simple present tense doesn't need temporal modification or a context to provide the t, since t is taken to be t_s, the moment of speech, in that case.) Put another way, we can, in the simple and progressive tenses, make statements to the effect that such and such an event occurred or will occur and statements to the effect that such and such a state of affairs obtained at some prior time point t or obtains now or will obtain at some future time point t, but not that such and such a state of affairs obtained (at some unspecified $t < t_s$) or will obtain (at some unspecified $t > t_s$).

We might at this point say something about the missing member of this array, i.e., statements to the effect that such and such an event "occurs" at the present moment. Bennett and Partee (1978) refer to the distinction between statements that assert that an event (-token) occurred, (occurs) or will occur and those which assert that an event (-type) habitually or frequently occurs as the reportive/non-reportive distinction. We normally use an event proposition in the present tense in the non-reportive sense. Event propositions in the simple past and future tense can be used with either a reportive or a non-reportive meaning. (William was ahead of his time in the matter of hygiene. He brushed his teeth and bathed once a month. vs. William got up at 6:00 yesterday, brushed his teeth and left the house before 6:30.) We can therefore have each of

i) event propositions in the non-reportive sense in a simple tense,

ii) event propositions in a progressive tense (which I will argue are state propositions), and

iii) state propositions in a simple tense

in the past, present, or future, but event proposition in the reportive sense in a simple tense only in the past or future. Bennett and Partee explain this gap by saying that since most events have some duration, we can't assert that they 'occur' now, since that would require that they occur instantaneously.

But what, then of 'punctual events'? I can use "John died yesterday at 3:00." in the reportive sense. But I don't think that "John dies." is something that Bill, at John's death bed, would shout into the next room at the moment at which the event occurs to report that the event had occurred. There simply is no reportive, simple present for event propositions in English since the situation where it could conceivably be used so seldom arises. It would be impossible, after all, to utter a sentence reporting an instantaneous event in an instant, and we tend to try to mark such occasions ("Tell me when the light comes on.") by shouting "Now!" or making a noise. And we have other ways to report that a durative event is now occurring.

The Classification of Propositions

In order to move toward the formulation of a formal system which more nearly reflects the use of tense and aspect in English, we will find it useful to distinguish at least the following seven classes of propositions, for which I introduce the notation $E_{\bar{C}\bar{A}}$, $E_{\dot{C}A}$, E_A, $S_{t(t)}$, $S_{t(p)}$, $S_{p(t)}$ and $S_{p(p)}$:

Completed action event propositions, which may be either durative or punctual:

$E_{\bar{C}A}$ (durative): Leonardo painted the Mona Lisa.

$E_{\dot{C}A}$ (punctual): Leonardo died.
(This distinction is important for aspects of tense that I will not deal with in this paper.)

Activity event propositions:

E_A: John danced.

State propositions: State propositions of the form $f(x)$ where x is an individual and f an attribute (which may be of the form $q(-, y_1, \ldots y_{n-1})$ for some n-place predicate q) may be further sub-classified by considering the propositions p_1 = "x exists" and $p_2 = f(x)$ separately. I will say that $f(x)$ is a permanent- or temporary-attribute state proposition depending on whether or not p_1 at $t \supset p_2$ at $t \ \forall t \in T$, and that $f(x)$ is a permanent- or temporary-argument state proposition depending on whether or not p_1 at t is true $\forall t \in T$:

$S_{t(t)}$ (temp att-temp arg): John is sick.

$S_{t(p)}$ (temp att-perm arg): God is angry. (?)

$S_{p(t)}$ (perm att-temp arg): John is English.

$S_{p(p)}$ (perm att-perm arg): 2 is a prime number.

I will let
$$E_{CA} = E_{\bar{C}A} \cup E_{\dot{C}A}$$
$$E = E_{CA} \cup E_A$$
$$S_{t(\ )} = S_{t(t)} \cup S_{t(p)}$$
$$S_{p(\ )} = S_{p(t)} \cup S_{p(p)}$$
and
$$S = S_{t(\ )} \cup S_{p(\ )}.$$

"Subjectless" state propositions like "It is dark." seem to behave like elements of $S_{t(p)}$. The classes E_{CA}, E_A and S are probably the same as the classes of performance, activity and stative propositions, respectively, in the philosophical literature. If $f(x) \in S_{t(t)} \cup S_{p(t)}$ and x denotes a person, I take "x exists" to mean "x is alive." That x must be the subject of the sentence is indicated by sentences like:

1) John's father is/was a country doctor.

and

2) John is/was the son of a country doctor.

1) and 2) have the same tense if father and son are both living or both dead, but if one is alive and one dead, the sentences have present or past tense depending on whether the subject of the sentence is living or dead.

It is not always easy to decide how to classify a given proposition and, indeed, a proposition may belong to different classes on different readings. I have not attempted to give other than very intuitive definitions of the seven classes and will, instead, suggest a number of semantic and syntactic "tests" which will serve at the same time to give properties of propositions in the various classes and to provide operational definitions of those classes. In formulating the tests, I will let pres(p), past(p), fut(p) and prog(p) represent atomic sentences in the simple present, simple past, future tenses and in the progressive, respectively. It is important to note that we are considering here propositions that do not contain temporal modifiers; the elements of $S_{t(t)}$ are propositions like "John was sick.", not "John was sick when Mary got home." I have made no particular attempt to systematize these tests and undoubtedly some are just different versions of a more general test:

1) "Is it true that past(p)?" makes sense in isolation:

Yes: $p \in E_{\bar{C}A}, E_{\dot{C}A}, S_{p(t)}$

No : $p \in E_A, S_{t(\;)}$

$p \in S_{p(p)}$ has no past tense.

For $p \in E_A$, the question makes sense only in a non-reportive sense: "Did your grandfather drink?"

2) p has no reportive simple present:

Yes: $p \in E$
No : $p \in S$

3) p has no progressive:

Yes: $p \in S$
No : $p \in E$

4) "past(p) and past (q)" means $P(p) \wedge P(q)$:

Yes: $p \in E_{CA}, S_{p(t)}$
No : $p \in S_{t(\ )}, E_{A(?)}$
p in $S_{p(p)}$ has no past tense

5) "past(p) and past(q)" means $P(p \wedge q)$

Yes: $p \in S_{t(\ )}, E_{A(?)}$
No : $p \in E_{CA}, S_{p(t)}$
p in $S_{p(p)}$ has no past tense.

6) One can say "pres(perf(p)) since t" for $t < t_s$:

Yes: $p \in E_A, S_{t(\ )}$
No : $p \in E_{CA}, S_{p(\ )}$

7) one can say "past(p) until t" for $t < t_s$:

Yes: $p \in E_A, S_{t(\ )}$
No: $p \in E_{CA}, S_{p(\ )}$

8) "past(p) because past(q)" $\supset \Omega(q) < \Omega(p)$

Yes: $p \in E_{CA}, E_{A(?)}$
No : $p \in S_{t(\ )}, S_{p(t)}$
$p \in S_{p(p)}$ has no past(p)

9) "past(p) because past (q)" $\supset p \wedge q$ true for some $t < t_s$:

Yes: $p \in S_{t(\ )}, S_{p(t)}(?)$
No : $p \in E_{CA}, E_A(?)$
$p \in S_{p(p)}$ has no past (p)

10) temporal connective + tense(p) is a temporal modifier:

Yes: E_{CA}

No : $S_{p(\ )}$

?: $p \in E_A, S_{+(\ )}$

11) If p = NP VP, one can say "NP started VP'ing":

Yes: $p \in E_{\bar{C}A}, E_{\dot{C}A}(?), E_A$

No : $p \in S$

12) if p = NP VP, one can say "NP is in the process of VP'ing":

Yes: $p \in E_{\bar{C}A}, E_{\dot{C}A}(?)$

No : $p \in E_{A(?)}, p \in S$

13) If p = NP VP, one can say "It took NP two hours to VP":

Yes: $p \in E_{\bar{C}A}, E_{\dot{C}A}(?)$

No : $p \in E_A, S$

14) One can say "past(p) for two hours.":

Yes: $p \in E_A, S_{+(\ )}$

No : $p \in E_{CA}, S_{p(\ )}$

15) If p = NP VP, one can say "NP just past(VP)" where just means "just now."

Yes: $p \in E_{CA}$

No : $p \in E_A(?), S$

The Formal System L

We are now in a position to articulate certain claims about the tense and aspect of the various types of propositions in English and to consider the shape of a formal system which would fit natural language, with respect to these claims, better than PCK does.

By applying the tests in the previous section, we see that the present progressive of elements of E behave in all cases like the simple present of temporary-attribute state propositions. Moreover, for these two kinds of propositions, pres(prog(p)) for $p \in E$ and pres(p) for $p \in S_{t(\ )}$, we feel no uneasiness about deciding whether or not they are true at a given $t \in T$, and these are the only kind of propositions for which this is the case. If we define Ω, then, to be a function which assigns to each such proposition a truth interval and give truth conditions for other kinds of propositions in terms of those truth intervals, the interpretation of Ω will be free of the problems we had with PCK. We define, therefore, a simple formal system, which I will call L, as follows:

A. $L = \langle V, O, M, \Omega \rangle$ where

i) $V = E_{CA} \cup E_A \cup S_{t(\ )} \cup S_{p(t)} \cup S_{p(p)}$

is a non-empty set whose elements we call tenseless propositions,

ii) O, the set of sentential "operators", is the set {Pres, Prog, P, F},

iii) $M = \langle T, < \rangle$ where T is a non-empty set and $<$ a linear order on T such that T with $<$ has the properties of the reals with "less than".

B. Let $Prog(E) = \{Prog(p) : p \in E\}$

and $Pres^* = \{Pres(p) : p \in S \cup Prog(E)\}$

We define the set Wff to be the union of the sets

$Wff_1 = \{(p, t) : p \in Pres^*, t \in T\}$

$Wff_2 = \{(P(p), t) : p \in E_{CA}, t \in T\}$

$Wff_3 = \{(F(p), t) : p \in E_{CA}, t \in T\}$

$Wff_4 = \{((P(p), t_1), t_2) : p \in S_{t(\ )} \cup Prog(E) \wedge t_1, t_2 \in T \wedge t_1 < t_2\}$

$Wff_5 = \{((F(p), t_1), t_2) : p \in S_{t(\ )} \cup Prog(E) \wedge t_1, t_2 \in T \wedge t_2 < t_1\}$

$Wff_6 = \{(P(p), t) : p \in S_{p(t)}, t \in T\}$

$Wff_7 = \{(F(p), t) : p \in S_{p(t)}, t \in T\}$

C. $\Omega : Pres^* \rightarrow 2^T$ (i.e. Ω assigns to each $p \in Pres^*$ a subset of T) and for $p \in S_{p(p)}$, $\Omega(p) = T$.

D. We give truth conditions for elements of Wff as follows:

i) $(p,t) \in Wff_7$ is true if $t \in \Omega(p)$ and false otherwise.

ii) $(P(p), t) \in Wff_2$ is true if $\Omega(Prog(p)) \neq \emptyset$ and $\Omega(Prog(p)) < t$, and false otherwise. (If $T_1 \subseteq T$ and $t \in T$, $T_1 < t$ if $t_1 < t \ \forall \ t_1 \in T_1$ and similarly for $t < T_1$)

iii) $(F(p), t) \in Wff_3$ is true if $\Omega(Prog(p)) \neq \emptyset$ and $t < \Omega(Prog(p))$, and false otherwise.

iv) $((P(p), t_1), t_2) \in Wff_4$ is true if $(Pres(p), t_1)$ is ture and false otherwise.

v) $((F(p), t_1), t_2) \in Wff_5$ is true if $(Pres(p), t_1)$ is true and false otherwise.

vi) $(P(p),t) \in Wff_6$ is true if $(Pres(p),t)$ is false and $(Pres(p),t')$ is true for some $t' < t$.

vii) $(F(p), t) \in Wff_7$ is true if $(Pres(p),t)$ is false and $(Pres(p),t')$ is true for some $t' > t$.

I have left the logical connectives ~, v, ∧, →, and ↔ out of L to avoid complications involving the relative scope of those operators and tense operators. L is therefore a grammar of atomic propositions. L has no provisions for perfect and non-reportive tenses, and the elements of V must be interpreted as tenseless propositions with no temporal modification. Let us consider, however, how well L, as far as it goes, fits our intuitions about tense and aspect.

Elements of V are to be interpreted as tenseless, atomic propositions, elements of E_{CA} as completed-action event propositions, etc., Pres(p), P(p), and F(p) as the present, past and future versions of $p \in V$ and Prog(p) as the progressive of p. There are no elements of Wff containing Prog(p) for $p \in S$ or Pres(p) for $p \in E$. Since the domain of Ω is Pres*, there is no problem interpreting or deciding about the membership of the sets $\Omega(p)$ for $p \in$ Pres*. Pairs of the form (P(p), t) or (F(p),t) for $p \in S_{p(p)}$ are not in Wff. Pairs of the form (P(p),t) or (F(p),t) for $p \in S_{t(\ )}$, which represent statements like "John was sick." (in isolation), are not in Wff. p for $p \in S$ and Prog(p) for $p \in E$ are treated alike. The truth conditions for the past and future of the various types of propositions correspond to our intuitions about such propositions, with the exception of $p \in S_{p(\ )}$. Much more satisfying truth conditions for P(p) and F(p) for $p \in S_{p(\ )}$ can be given on a presupposition analysis, with, however, considerable complication of the system. Because L does not give truth conditions for the perfect tenses, we have not handled the problem of the difference between completed action and activity propositions regarding the entailment (Prog(p), t) ⊃ (present perfect(p), t). Finally, we note that L differs significantly from "interval semantics" in the treatment of the relationship between the present tense and the progressive aspect.

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