This is to certify that the

dissertation entitled

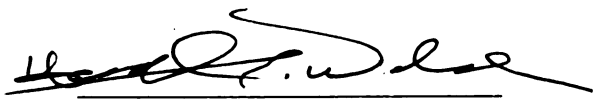
A Study In The Temporal Ontology of Tense Logic

presented by

David J. Zacker

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Philosophy



Major professor

Date 3/25/96

DATE DUE	DATE DUE	DATE DUE
FEB 2 6 1997 IL-16234582		
[illegible]		
[illegible]		
MAY [illegible]		

A STUDY IN THE TEMPORAL ONTOLOGY OF TENSE LOGIC

By

David J. Zacker

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Philosophy

1996

ABSTRACT

A STUDY IN THE TEMPORAL ONTOLOGY OF TENSE LOGIC

By

David J. Zacker

In his 1957 work, *Time and Modality*, Arthur Prior reflects on the Barcan Formulas (so called after Ruth Barcan Marcus) "$P(\sum x)A \rightarrow (\sum x)PA$" and "$F(\sum x)A \rightarrow (\sum x)FA$". Take "P" to be read "It was the case that", "F" to be read "It will be the case that", and "$(\sum x)$" to be the existential quantifier. The former formula can be read "If it was the case that there existed something such that A is true, then there exists something such that it was the case that A was true". In order for the formula to hold, whenever there was something that existed that made the formula A true, it must be true that there is something currently existing that makes A true. Prior's tense logic was a direct response to this unintuitive result for modal and tense logics: he thought that the Barcan Formulas should not hold.

Whether or not one agrees with Prior may depend on what one takes as existing. For example, if one were to hold that past individuals do in fact exist, then the former Barcan Formula would seem unproblematic. Similar things can be said for the latter Barcan Formula. Special relativity is usually taken to suggest that this is the case, namely, all individuals past, present, and future, all exist in the four-

dimensional spacetime continuum. Nino Cocchiarella took this view in his 1966 dissertation. In that work Cocchiarella developed a tense reflecting his intuitions.

I argue that special relativity does not commit one to such a view of spacetime. Instead, we should take only presently existing individuals as existing. I reconstruct Prior's primary tense logical system from its axiomatically presented modal fragment. I then evaluate this system in light of my view of time. Next, I reconstruct Cocchiarella's tense system in the same terms with which I reconstruct Prior's logic. Then I evaluate that system. I conclude that both systems lead us to radically solipsistic results. In the final chapter I suggest some lines of inquiry in special relativity that may lead to a solution for the problems that Prior's system and Cocchiarella's systems face.

This is dedicated to my fellow graduate students from Western Michigan University and Michigan State University: without you, my friends, I would not be what I am today.

ACKNOWLEDGMENTS

First of all, I'd like thank the Philosophy Department of Middle Tennessee State University for their material support and for allowing me the time to finish this work during my first semester as a member of their department. Also, I'd like to thank the Graduate College of Michigan State University for a Dissertation Completion Fellowship which allowed me the time to bring my ideas together.

The Philosophy Department at Michigan State University arranged for appreciated financial support throughout my doctoral studies. With the passing of Herbert Hendry, they provided excellent help bringing this project to completion despite this great loss. For this, I thank them dearly. In particular, I'd like to thank the members of my committee, Harold Walsh, Richard Hall, Joseph Hanna, and Barbara Abbott; thanks also goes to David Dwyer, of the Department of Linguistics.

A special thanks goes to Herbert Hendry whose moral, intellectual, and conceptual support propelled this project from its infancy to completion. He will be greatly missed.

A special thanks goes to my children: Abby, for waiting until after my defence to be born; and Benjamin for sleeping at regular intervals as an infant and for bringing a smile to my face. The biggest thanks is reserved for my wife, Molly MacKay-Zacker, for her unqualified support. Without her,this might have never been completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Standard Logical Notation

"-"	Negation
"→"	Conditional
"↔	Biconditional
"&"	Conjunction
"v"	Disjunction
"⇒"	Implies
"⊇"	"Is a subset of"
"∈"	"Is an element of"
"}"	"It is a theorem that"

Quantificational Notation

"="	Identity
"e"	An evaluation
"(v)"	The universal quantifier, "For all v such that"
"[v]"	Cocchiarella's universal possible quantifier, "For all v such that"
"(∑v)"	The existential quantifier, "There exists a v such that"
"[∑v]"	Cocchiarella's existential possible quantifier, "There exists a v such that"
"()A"	The universal closure of the wff A.
"Q(**v**)"	The predication "$Q(v_1 \ldots v_n)$"

Tense Logic Notation

"F"	"It will be the case that"
"G"	"It always will be the case that"
"H"	"It always has been the case that"
"P"	"It was the case that"
"S"	"Is Statable"
"T"	"It will always be statable that"
"Y"	"It was always statable that"

LIST OF ABBREVIATIONS

CO	Comprehensive Objecthood
DR	Degrees of Reality
DT	Dynamic Theory of Time
IPPS	Internal Present-Point Solipsism
MSP	The Man On the Street Principle
PPS	Present-Point Solipsism
SB	Strong Becoming
SR	Special Relativity
WB	Weak Becoming
WFF	Well-formed Formula
WLS	World-line Solipsism

CHAPTER 1

INTRODUCTION

1 THE PROBLEM

Gerald J. Massey begins his article "Tense Logic! Why Bother?" with the following passage:

> According to historians like Thomas Kuhn, the story of a scientific revolution is a chronicle of disenchantment with a paradigm, often nurtured by nostalgia for bygone ideals, culminating in the production of a rival paradigm which ultimately wins the allegiance of the relevant scientific community away from the older paradigm through a process akin to American politics. What is thus true of revolutions in empirical science is no less true of revolutions in the formal sciences of logic and mathematics, and it so happens that a logical revolution is well underway today (Massey 1969, 17).

The revolution to which Massey refers is the revolution of tense logic. Tense logic is an alternative logic which is, firstly, designed to take tensed propositions seriously, and secondly, modeled on the concepts of modal logic.[1]

This revolution by tense logicians is motivated by the alleged mishandling of time in modern logic. The bygone ideals that modern logic apparently does not heed are those of medieval logicians such as Diodorus Cronus who argued that proposition which change their truth values over time, not eternally true or false propositions, are the

---

[1] This assumes that propositions can be, in fact, tensed. I briefly discuss this in Chapter 3, section 2.4.

proper basic units of logic. Therefore, it is alleged, a proper handling of such *temporal* propositions by logic must include tense. Some argue all logic is definable in tense logical terms. For instance, A.N. Prior argues that tense logic should not be thought of as secondary to standard logic, but should itself be thought of as logically primary to standard logics (Prior 1968, 101).

In a 1941 article J.N. Findlay maintained that "our conventions with regard to tenses are so well worked out that we have practically the materials in them for a formal calculus" (Findlay 1968, 143). Such comments may lead one to believe that a tense logic would be quite easy to work out. On the contrary, Prior, for instance, did not take logic to be about the conventions of language as much as it is about the real world; the tense logic to which one adheres must be metaphysically pleasing.

There are many problems with developing such a system, one of the most vexing of which is the problem of possibly denotationless terms and which individuals should count as the legitimate values of bound variables. In particular, should individuals like Socrates, the Tower of Babel, and other past, but not present, individuals be quantified over? Should individuals like my first grandchild, the house that my first grandchild buys, and other future, but not present, individuals be quantified over? Assuming that one should only quantify over existing individuals, the answers to these questions rest on whether you take such individuals to exist in some significant way. There is no generally accepted resolution.

It is here that Massey most severely criticizes Prior's approach (Massey 1969, 30). Massey argues that Prior does not take thee physics

of time seriously despite the fact that he proclaims to take time seriously (Massey 1969, 28). It is here that Massey delivers his decisive blow against the Priorean approach to logic. This is not to say that these are his only criticisms of Prior, and the enterprise of tense logicians, in general. In fact, he argues that tense logic itself is ill-conceived, regardless of one's approach.

I will use the physics of time as my point of departure. In particular, I want to examine Massey's criticism of Prior's apparent neglect of the physics of time. I will address that argument in terms of the authors he relies on, namely, Hilary Putnam and W.V. Quine. In particular, I will address the view of time informed by the special theory of relativity and draw some conclusions about time. I will conclude, contrary to Massey *et al.*, that special relativity does not imply that time is space-like. As I alluded to above, Massey *et al.* argue that if time is space-like, then Prior's approach is misguided. Since I deny the antecedent I conclude that it cannot be on such grounds that we criticize Prior's approach. In fact, I will argue, that based on the conclusions I draw about time, a Prior-like approach is appropriate.

I believe my argument holds with the following assumptions. First of all, the conclusion that time is not space-like implies that nonpresent individuals do not exist. This is, for Prior, the primary motivation for his project. For, if nonpresent individuals do not exist, one should not quantify over them. If one cannot quantify over them, then tensed assertions about nonpresent existents must take this into account. But this is precisely what standard predicate logic does

not do. Therefore, some sort of tense logic seems in order. But what sort?

I explain the uncontested assertion that Cocchiarella-like systems quantify over nonpresent individuals. Therefore, Cocchiarella-like systems are dependent upon the space-like interpretation of time. If that interpretation of time is shown to be misguided, then we may claim Cocchiarella's attempt is misguided. Therefore, given the two primary types of tense logic, Prior-type and Cocchiarella-type, only the Prior-like approach is adequate to provide a system sensitive to the nature of time. Nonetheless, I also conclude that Prior's actual system, QQK_t is inadequate, for a number of reasons.

2 ESSAY OUTLINE AND CONCLUSION

It is the purpose of this inquiry to examine the common scientific theory on which criticisms of tense logic are based, and to then evaluate two types of tense logic in respect to the results of the inquiry into that basis. In particular, I examine the implications of special relativity concerning the ontological status of nonpresent individuals. I then evaluate the tense logic systems of Prior and Cocchiarella, the two logicians exemplifying two fundamentally different ways of handling nonpresent existents. A chapter-by-chapter outline is as follows.

In Chapter 2 I examine what can be concluded about the ontological status of past, present, and future individuals based on the results of special relativity. I conclude that special relativity is consistent with the nonexistence of past and future, but not present, individuals.

Moreover, I invoke an empirical argument for the conclusion that, in fact, such individuals do not exist.

In Chapter 3 I examine Prior's tense logical system QQK_t. I begin by examining the intuitions which led Prior to question established tense logical systems. I then give a semantic reconstruction of QQK_t from the axioms and rules he laid out in his book *Essays on Time and Tense*. I leave the evaluation of Prior's system to Chapter 4 where I evaluate it first on logical grounds and then in respect to the results about temporal ontology I draw in Chapter 2. I conclude that Prior's system fails for three primary reasons: QQK_t leads to very unintuitive translations; it flies in the face of the rules of definition; and it leads to radical solipsism.

In Chapter 5 I present Cocchiarella's tense logical system APK_t using his semantics, but I frame it in the notation I used in reconstructing QQK_t. The similarity of presentation allows for clearer comparisons of the logical structures of APK_t and QQK_t. Thus I draw comparisons between the two systems in order to lay bare APK_t's consequences. I go on to argue that APK_t falls into the same sorts of solipsistic pits which plague QQK_t. Moreover, APK_t is not adequate to handle a tensed ontology.

Thus, I argue that neither exemplification of the respective types of tense logic will do as they stand. In the sixth and final chapter I lay out some suggestions for what would have to be accomplished to provide an adequate system. I will save such considerations for the final chapter, however, as they do not form the substantive portion of this essay. The remainder of this introduction is devoted to the

explanation of the basic distinctions and vocabulary necessary to address these issues.

3 THREE BASIC DISTINCTIONS

Three basic distinctions provide grounds for the organization of this inquiry: the first distinction is that between the *tenser* and the *de-tenser*; the second is that between the *P-tenser* and the *C-tenser*; and the third is that between the C-tenser and de-tenser, on the one hand, and the P-tenser, on the other. I will treat each distinction in turn.

3.1 FIRST DISTINCTION: TENSER v. DE-TENSER

As stated in the opening paragraphs, some logicians are attempting to affect a revolution in logic by winning over logicians with a new paradigmatic view of logic, viz., that logic is incomplete without an adequate treatment of tense. They appeal to temporal considerations on the truth values of propositions. They argue that since certain propositions change their truth values over time, a system of logic insensitive to such considerations is deficient. In Chapter 3 when addressing some objections to Prior's tense logic I address these considerations in more detail. Following Massey, I will hereafter refer to those who attempt to take seriously considerations of tense through tense logic as *tensers*, and those who criticize such attempts as *de-tensers* (Massey 1969, 18).

3.2 SECOND DISTINCTION: P-TENSER v. C-TENSER

Massey draws a distinction within the tensers, between Prior-like tense logicians, and Cocchiarella-like tense logicians, or in his

parlance, *P-tensers* and *C-tensers*. On the one hand, P-tensers challenge the propriety of quantifying over past but not present individuals, and future but not present individuals. On the other hand, C-tensers take such quantification to be without insurmountable problems. Therefore, the guiding distinction is in the individuals that they allow as legitimate values for bound variables.

3.3 THIRD DISTINCTION: DYNAMIC v. NEO-ELEATIC CONCEPTIONS OF TIME

As both P-tensers and C-tensers take logic to be about reality, and the tense logician tries to be sensitive to temporal ontology, a consideration of the metaphysics of temporal ontology is necessary when considering the first two distinctions. Some argue that there is a privileged point in time, distinguished by the transient Now. All existence is at the point of the transient Now, and things come into existence and pass out of existence as the now moves along the continuum of time.

Some thinkers take such views of time as support for the tenser view of logic. For, "Lou Gehrig *was* the baseball player who held the record for the most consecutive games", "Cal Ripken *is* the baseball player who holds the record for the most consecutive games started", and "Joe Baseball *will be* the ...", where Joe Baseball lives in the future but not now, all depend on tense for their truth values. Individuals (or events) *existed*, *exist*, or *will exist* relative to a Now. And what we can say about them depends on a complex set of relations between their temporal existence, and the status of the claims made about them. P-tensers fall into this camp.

C-tensers and de-tensers, on the other hand, hold that there is no transient Now: there is no privileged point in time that picks out all existence. Instead, time is just one part of the four-dimensional manifold which includes the three dimensions of space. Without a privileged point in time to pick out existence, all things just exist, tenselessly.

De-tensers and C-tensers accept eternal truth values for propositions about nonpresent existents. Since all objects exist in the tenseless sense, claims can be made about them at any time. Therefore, it makes sense to speak of propositions, or whatever one takes as the bearers of truth, about contingent beings as having eternal truth values. This distinction in views of time can be expressed in terms of John McTaggart's distinction between the A-series and the B-series in time. I will explain each in turn.

3.3.1 McTAGGART'S A-SERIES

John McTaggart wrote a very influential article at the turn of the century which has colored how we have viewed time ever since. He argued that there are two ways of conceiving of time. The first is the way in which we experience time. Time is defined by the *determinates* past, present, and future. All events and/or objects can be classified according to whether they exist in the past, in the present, or in the future. So, for instance, the next World Series is in the future, while the last World Series is in the past, and Cal Ripken's breaking Lou Gehrig's record of consecutive games started is present (as that is happening as I write this). Thus, these three events have the determinates of future, past, and present, respectively.

One result of viewing time in this way is that determinates are applicable to events relative to a time. Thus, one day ago Cal Ripken's breaking the record had the determinate of future, just as the next World Series does, the last World Series had the same determinate as before, viz., past, and some other event, say, my outlining this passage, had the determinate present. In the future, the present and future of these events will change their respective determinates, again. In fact, all events in the past relative to the present, whichever and whatever that present is, have had the determinates future and present at different times, and currently have the determinate past. These determinates McTaggart calls the *A-determinates*. We can represent the *A-series*, the ordering of events according to A-determinates, graphically as in Figure 1.1.

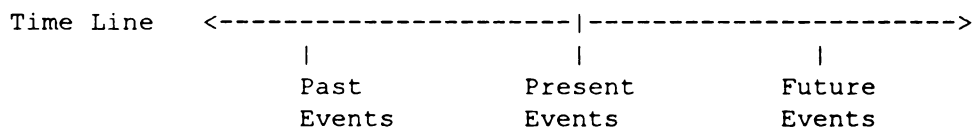


Figure 1.1: All events can be classified according to their temporal location in accord with the A-determinates past, present, and future. The determinates attributable to particular events change over time.

3.3.2 McTAGGART'S B-SERIES

McTaggart contrasts the A-determinates with another set of determinates *before* and *after*, which he calls the B-determinates. All events, according to McTaggart, have these *B-determinates* relative to other events. So, for instance, the last World Series has the B-determinate *before*, relative to Cal Ripken's breaking the consecutive games started record; and Cal Ripken's breaking the record has the B-

determinate *after*, relative to the last World Series; the next World Series has the B-determinate *after*, relative to both of the other two events; and both of those events have the B-determinate *before*, relative to both of the other two events. Moreover, according to McTaggart, these relations expressed by the B-determinates are eternal, that is, they never change, relative to two distinct events. Figure 1.2 represents the B-series according to McTaggart.

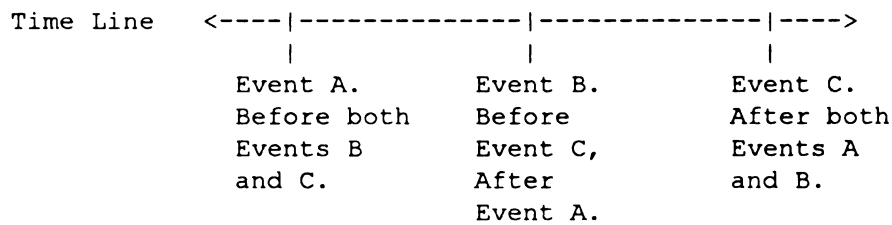


Figure 1.2: All events can be classified according to their temporal location relative to other events in accord with the B-determinates before and after. B-determinates do not change over time.

Thus McTaggart distinguished these two ways of conceiving of time. The temporal theorist may take either series as primary and the other as secondary. Taking the A-series as primary is to hold a *dynamic* theory of time, that is, in the sense corresponding with our experience of time's passing: events happen; objects exist for temporally specific times, and then cease to exist. On the other hand, one may take the B-series as primary. Such a conception is similar to the view, held by Parmenides, that the universe is eternal and unchanging; we only *experience* it as temporal, changing, and dynamic. I call the modern proponents of such a theory of time *neo-Eleatics*, and their view the *neo-Eleatic view of time*.

3.3.3 PARADIGMS OF TIME

Massey points out that there are Kuhnian paradigms which serve to differentiate the outlooks on the value of tense logic. So, too, there are Kuhnian paradigms which serve to differentiate some of the philosophers who take the A-series as primary from some of those who take the B-series as primary. There are many reasons for arguing one way or the other: there are arguments based on conceptual analysis; there are arguments based on experience; there are arguments based on thermodynamics, entropy, quantum physics, and other scientific concepts. In this inquiry I wish to examine arguments from the perspective of the special theory of relativity.

I do so, in part, because of Quine's and Massey's belief that special relativity implies the undesirability of tense logic. Quine wrote "the special theory of relativity leaves no reasonable alternative to treating time as space-like" (Quine 1960, 172). Thus, past and future individuals and/or events have existence. Thus, instead of cluttering our logic with unnecessary logical notation designed to handle a complicated temporal ontology, we should simply use standard propositional logic or standard predicate logic. No revisions to standard logics are necessary based on the concerns of temporal ontology. With this view in mind it is time to move onto the arguments. Is time dynamic or neo-Eleatic?

CHAPTER 2

TEMPORAL BECOMING AND TENSE LOGIC

1 INTRODUCTION

The P-tenser is at odds with both C-tensers and de-tensers over the ontological status of temporally located objects.[2] The P-tenser maintains what Putnam calls *the man on the street principle* (hereafter, MSP):

MSP: All (and only) present objects exist.[3]

MSP is the common sense view that future objects, e.g., the first new car I purchase, do not yet exist, and past objects, e.g. my first bicycle, no longer exist. The only objects which exist are those which

---

[2] "Object" and "events" are used at different times in this chapter when referring to ontology. Typically, dynamic theorists take events as ontological primative, while neo-Eleatics take objects as ontological primatives. I will take objects as primative for two reasons. First of all, I take the existence of events as presupposing that they happen to some objects, thus presupposing objects. Therefore, I will take any mention of events as presupposing the existence of some object, or objects. Secondly, the status of objects bears on the issues relevant to the discussion of tense logic which follows. Nonetheless, while one's choice of ontological primatives may have a significant bearing on related issues, they do not bear directly on the subject of this essay.

[3] Putnam's quote is that "All (and only) things that exist now are real". However, I feel that this is a prejudiced statement, for it suggests that past and future things may have a sort of existence. I would rather not load the language this early. Moreover, I later distinguish three "degrees of reality" while Putnam's quote suggest only a binary distinction: things are either real or not. I will reserve this binary distiction for existence.

exist at the present moment in time, e.g. my walking shoes (Putnam 1967, 240).

On the other hand, the C-tenser and the de-tenser argue for the doctrine Prior calls *comprehensive objecthood* (CO):

CO: All past, present, and future objects exist.

Proponents of CO maintain that all objects, including my first bicycle, my walking shoes, and my first new car, have the same ontological status, they all exist (Prior 1957, 31). They all exist just as do the chair on which you are now sitting and the wall next to you. The only difference between the relationship between the bicycle, the shoes and the car in the first example, and the relationship between the chair and the wall in the second example is the spacetime dimensional relationships which the objects in each example share. The chair that you are sitting in and the wall next to you are merely spatially separated, while my first bicycle, my walking shoes and my first new car are temporally (as well as possibly spatially) separated. But, just as the chair and the wall co-exist, so do the bicycle, the shoes and the car. They stand, as Prior puts it, "timelessly in a variety of relations to *all* space-time regions" (Prior 1957, 31).

The choice between tense logic and classic predicate logic is made, in part, in accord with which ontological status one assumes of temporally-separated objects. For example, Prior argues that since neither future nor past individuals exist, they cannot be quantified over in the classical sense. Therefore, a logic sensitive to problems of temporal ontology must be constructed. On the other hand, Quine argues that "[special relativity] leaves no reasonable alternative to

treating time as space-like" (Quine 1960, 172). Therefore, he continues, past, present, and future individuals share the same ontological status, they all exist. Since Prior's ontological concerns are unfounded, Quine would maintain, all objects can be quantified over regardless of their spatial-temporal location.

The choice between P-tense and C-tense systems is also determined in part by these ontological questions. For, while the P-tenser accepts a dynamic theory (DT) of time, the C-tenser agrees with the de-tenser. Therefore, one can agree with Quine's view of temporal ontology while disagreeing with his conclusion that classical predicate logic is adequate to handle tensed assertions. I will not address the distinction between the C-tenser and the de-tenser in this chapter, as the differences do not find their roots in the issues of this chapter. I will only concern myself with temporal ontology, with which both groups of logicians are opposed to the P-tenser.

Quine argued against tense logic based on his view of spacetime as informed by special relativity (SR). He was joined in his ontological stance by others in the 1960's such as C.W. Rietdijk (1966), Putnam (1967), in the 1970's by Lawrence Sklar (1974), and in the 1980's by J.J.C. Smart (1980), and Nicholas Maxwell (1985 and 1989). All gave similar arguments. I feel that the essentials were most clearly expressed by Putnam. Therefore, I will hereafter address his formulation of the argument. A brief outline goes as follows.

Putnam argues that space and time make up a 4-dimensional manifold, three dimensions of space and one of time. Objects in the future for one observer, O_1, may be in the present for another observer, O_2, while O_2 is in O_1's present. Presumably, objects in an observer's

present must exist for that observer. If we take "existence for" to be a transitive relationship, that is, if x exists for O_2 and O_2 exists for O_1, then x must exist for O_1 even if x is in O_1's future! It follows from SR, then, either that only that particular object exists for itself and nothing else, or that regardless of space-time locations everything exists for every other object (Putnam 1967, 240, and Stein 1968, 5). If we want to deny the solipsism the first alternative presents, then everything must exist for everything else.

Opponents of CO, of which Quentin Smith (1985), D. Dieks (1988), and Howard Stein (1991) are recent examples of those who argue that the neo-Eleatic argument is "seriously misapplied" (Stein 1968, 5; 1991, 147). They then appeal to concepts such as *temporal becoming*, the *flow of time*, the *arrow of time*, the *passage of time*, the *transiency of the Now*, the *direction of time*, etc. Such concepts, they argue, imply DT and a dynamic view of events which happen to objects, thus presupposing objects, in time. Suppose, for example, that we see someone walking along the beach. Following her is a trail of footprints. Footprints *become* or *come into being*.[4] The event is comprised of a subset of events which make up the totality of that event, the making of individual footprints, which proceed in a certain order. We would find it strange if the series of events happened backwards, i.e., there were footprints which were already there and the walker, walking backwards,

---

[4] As acknowledged in a previous footnote, one could take events as ontologically prior. Augustynek is one such philosopher. Each event is comprised of many events. The making of each individual footprint is an event: her heel strikes the sand, the foot rolls forward and she pushes off of the ball of her foot, each step of which is itself an event. Generalized, such a view is called "point eventism" (Augustynek, 1). This is where all events can be divided into sets of simpler events and all events are part of more complex events.

always stepped in the footprints only to have them disappear upon lifting her foot. We would find it stranger still if it happened in some other order. It is most natural to conceive it as happening in a particular order, one directed by time. Through time the event happens, one footprint becoming after another. Temporal becoming is this dynamic succession of objects, the change from one state of a system to another, through time, as we experience it.

The P-tenser takes temporal becoming (hereafter, simply "becoming") and CO to be incompatible. For the doctrine of becoming includes the notion that future (past) objects are not yet (no longer) real or do not exist, i.e., MSP. This follows from the supposition that as time passes, future objects come into being, i.e., become. P-tensers do not mean by this that future objects inhabit some other realm of "not-being": they do not inhabit anything (Prior 1967, 137ff.). Future objects are more accurately thought of as not objects at all. The words we use to describe future objects have no denotation. They gain denotations as the denotations become. Therefore, objects of the future do not yet exist. Similar points can be made about past existents.

C-tensers and de-tensers do not deny the existence of becoming, but contrary to P-tensers, C-tensers and de-tensers argue that becoming is not part of the physical world; it is merely the way that conscious beings perceive the world. Hereafter I will refer to this notion of becoming as the *weak* conception, or *WB* for *weak becoming*, and the view in which becoming is part of the physical world the *strong* conception, or *SB* for *strong becoming*. WB *is* compatible with CO, for WB merely consists of how we experience the world, it is not part of the physical world. Therefore, to adequately address the differences between classic

logic and C-tense logic, on the one hand, and P-tense logic, on the other, we must look to becoming's relation to the physical world: should it be taken in the strong or weak sense?

As I have presented the arguments above, both sides beg the question. It is easy to see how the P-tenser has begged the question: the P-tenser assumes causality, which itself is wrought with temporal concepts. In the case of the C-tenser and de-tenser, however, the difficulty is not so clear. They have begged the question by setting up a false dichotomy which itself depends on the assumption that becoming is not part of SR. The dichotomy is this: one must either take all temporal orderings to be absolute, or none. I will show later that there is a third option not incompatible with a narrower notion of the Now, namely, that some orderings are absolute, while others may not be. I will explain the foundations for this dilemma in later sections.

While other physical theories ultimately might have some bearing on this question, I concern myself with SR because of the appeals common to logicians and scientists, instead of, say, arguments from thermodynamics, quantum mechanics, or even general relativity. SR was chosen by past logicians as proof of CO since it is a prominent physical theory which makes predictions about the local nature of temporal ontology. Therefore, in this chapter I will discuss the basic arguments for and against SB in relation to SR.

Before I do that, however, I must more fully explain the notion of becoming and how it connects with modern physical theory. In short, it connects through the notion of a *transient Now*, a point instant which picks out the present. Therefore, I will explain the transient Now in sections 2.1-2.2. In sections 3.1-3.2 I will explain the transient

Now's connection with physical mechanics. In sections 4-4.2.3 I will present the classic arguments for SB, as I feel that all subsequent arguments are based on the same notions as these classics. Along the way I will discuss the classic argument against SB. I assume here, as with the opposing arguments, that most subsequent arguments are based on the same notions as these classics. In section 5-5.2.4.2 I will discuss Milic Capek's argument that SR incorporates SB. Such a notion is opposed to a Newtonian absolutist account of time. Moreover, Capek's argument begs the question. Nonetheless, an objective account of SB can be provided based on his argument. Finally, in section 6.3 I will outline the notion of the transient Now with which the tenser must work. I will argue that it leads to a spatial-temporal point-instant which, as I mentioned above, suggests that for any object in the universe, only it exists for itself. The implications for are considered for P-tensers in Chapter 4 and for the C-tenser in Chapter 5. Now, however, let's address the physics of this issue: what is the relationship between SR and becoming?

2 THE TRANSIENT NOW

In the following sections I intend to show the connection between SB and the transient Now, and explain the notion of the transient Now in more detail. In section 2.1 I will show that SB includes the notion of the transient Now. In section 2.2 I will explain the Aristotelian transient Now, as it is the fundamental notion discussed in modern accounts of becoming.

2.1 SB AND THE TRANSIENT NOW

SB is the coming-into-being of objects *through time*. Nonexisting future objects begin to exist at the present moment, i.e., become. SB's intimate relationship with time necessitates an account of time which can make sense of how something can become at the present.

Imagine a time line with the time periods during which various objects exist marked below it. We can return to the objects discussed in an example above, viz., my bike, my shoes, and my car (see Figure 2.1).

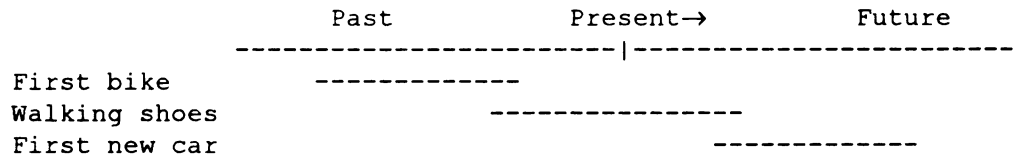


Figure 2.1

The Present moment is indicated on the time line. The area to the left of the moment marked as the "Present" is the "Past", and the area to the right of the Present is the "Future". According to the doctrine of SB, only objects at the Present have existence, while objects in the Past and the Future have no existence (even though we may have names for them). In Figure 2.1, then, my walking shoes have existence while neither my first bike nor my first new car do. As the Present "comes to future objects" those objects become. So, when the Present moment reaches my car, that car will become.

The figure is a spatial representation of a process which may itself not be spatial. The spatiality of the diagram may lead one to believe that relationships between past, present, and future objects have a spatial quality. In other words, it may appear that my car

exists but is located at a different "location", in the same way the wall and chair are at different locations. But as was mentioned above, that may or may not be. However, according to the doctrine of SB that cannot be: objects exist only at the present; we only speak of future and past objects *as if* they exist.

The present moment is often called the *Now*. The Now is the temporal division between the past and the future, the temporal location where objects exist. It is not a finite segment of time, but is the infintessimal divide, just as the point is the infintessimal divide between one side of a line and the other side. The entering of existence is a *dynamic* process, represented in Figure 2.1 as an arrow showing the direction of the Now. The movement of the Now represented in the figure is called its *transiency*. Thus, SB uses the notion of a transient Now where objects come into being or existence. Therefore, SB depends upon a transient Now; if a transient Now does not exist, then neither does SB. Moreover, to show the existence of the Now is sufficient to show SB, for by definition the Now marks off the point when objects become.[5] Therefore, the transient Now is a necessary and sufficient condition for SB. Since the Now plays such an essential role in this view of time, I will take some time to develop its classical conception.

---

[5] One could also say that the now marks off the point at which things unbecome. Surely, things go out of existence at the now point just as they come into existence at the now point. I suspect, although I have no textual support for this claim, that the word "becoming" was chose becasue of the connection between becoming and the discussions of future contingents. "Become" is often used discussing when claims become true or false. For example, Aristotle's "Seabattle" discussion is about if and when the claim "There will be a seabattle in the harbor tomorrow" becomes true or false.

2.2 ARISTOTLE

In this section I will explain the notion of the transient Now. Aristotle gave this notion its first rigorous formulation, one which I will use to represent the general features common to typical ideas of SB. Therefore, I will briefly explain Aristotle's formulation.

I will make five points which will help us understand the notion of the Aristotelean Now: (1) we perceive time by "counting Nows"; (2) however, there is only one Now; (3) the Now divides the past and the future into two well-defined portions of time; (4) the Now is not of finite size; and (5) the Now is the boundary between the past and the future. I will draw these points from a more general discussion about the structure of time according to Aristotle.

2.2.1 ARISTOTELEAN TIME

Aristotle wrote that "time is a number of change in respect of the before and after ..." (*Physics IV 11 220a24*). Taken in isolation, this quotation may seem to support the view that time is, in some way, reducible to change. But he explicitly rejects that notion for two reasons. First, change happens to something at a particular location, however time is everywhere. Second, change can be fast or slow, but time cannot. Instead, we measure the speed of change in reference to time (*Physics IV 10 218b18*). Indeed, some modern criticisms of a causal theory of time mirror the second objection: change and causality both presuppose time.

Nonetheless, Aristotle says that time can*not* be considered apart from change. When we awaken from a deep sleep, we do not feel that time has passed. Instead, we connect two moments, the last moment in which

we have awareness before falling asleep with the one of which we are immediately aware when we awaken, to form one moment. It is this failure to perceive change that leads us to believe that time has not passed. Only upon the realization of change in our environment or "in our soul" do we say that time has passed at all. So, we say that time passes when we "mark off an alteration" (*Physics*, IV, 11, 218b34). Therefore, Aristotle concludes, we do not conceive of time without change.

2.2.2 COUNTING NOWS

Aristotle says that it is this marking off of before and after that gives us the perception of time's passage. The mind *counts a Now* when it is immediately aware of the present. Upon becoming aware of change or movement it counts a second Now. To count a second Now is to note two distinct Nows, that is, a Now before and a Now after. Thus, the passage of time is noted by our perceiving the change from the before-Now to the after-Now. Therefore, point (1): we mark off time by counting Nows.

2.2.3 A SINGLE NOW

Although he says that there are distinct Nows, this is not literally what he means. Instead, he suggests that there is a single, moving Now, i.e., point (2). In order to explain how we can say that two Nows are different and yet the same, he draws an analogy between the moving Now and a body in motion. We can describe a body in motion by describing it at one place and then another. Thus, we predicate different objects of the same body. In the same way, we can describe

the Now's motion by taking it as at one world state and then at a subsequent world state, one that shows some change from the preceding one. In other words, we can predicate different world states of the Now point. So, in one sense, the Nows are different in the same way that the moving body is different at one point in its motion from another point in its motion. On the other hand, just as the body is in one sense the same body at different points, the Now is the same Now at different points on the before and after continuum.

2.2.4 BEFORE AND AFTER, AND PAST AND FUTURE

(3), the moving Now point divides the before and after into two well defined portions of time. Consider Figure 2.1 again. Everything to the left, or before, the Present (the Now) is temporally before; and what comes to the right, or after, the Now is temporally after. Thus, we can also divide time into past and future. The past is before the Now and the future is after it.

2.2.5 ARISTOTELEAN TIME, AGAIN

We are ready to formulate Aristotle's meaning when he wrote that "time is a number of change in respect of the before and after". Time is not change, but cannot be conceived of without change. In fact, it is when the Now "moves" along the before and after continuum, when we count "different" Nows, that we can say that time has passed. Time then is number -- in the sense that we count successive Nows, not that it is a number as one, two, three, etc. are numbers -- which we count as change occurs. Again, this is not to say that we have different Nows in the literal sense. Instead, time has, as its substrate, a Now; and,

just as we predicate different things of substrate body as it changes location, viz., we at the least predicate different locations of the substrate, we predicate different things of the substrate of time, the Now, when change has occurred. This is not to say the we can only predicate different locations on the time continuum, that is "times" of the Now, for that would be circular. We must also be able to predicate different world-states of the Now, that is, there must have been some change in the world to view time as having passed.[6]

2.2.6 INFINTESSIMAL NOW

Nonetheless, (4) the Now is not itself of measurable size, that is it does not have a finite magnitude. For, as Aristotle points out, if it was of measurable size, it could itself be divided into a past and a future; the past and the future are unreal, according to Aristotle; therefore, the unreality would be passed to the Now, making it, and therefore time, unreal (220a 19-20; Miller, 133-134; Capek 1991, 44). Along the same lines, in a 1956 article Russell pointed out that it cannot be of a certain size, i.e., it cannot have extension, since to have extension it must by definition be dividable into simpler parts (Russell 1956, 189-190). But, then the now could be divided by time. But that is clearly not what is desired. Time is made up of Nows, just as the line is made up of points, that is, time is made up of Nows in a figurative sense.

---

[6] Whether one predicates different world-states of the now or different nows of world-states is, I believe, tantamount to the question of whether time is dynamic or static. For, Aristotle argues that the now is a unique point, on the before and after continuum, which divides the past and the future; if it were not unique, then there would be many nows and thus "the" present could not be defined.

Therefore, point (5) it is a boundary, not an entity such as a duration, a part of time, or anything else of such ilk. Again, consider Figure 2.1. The Present is not an entity of finite size, but is the dividing point between the past and the future. In other words, the Now is of the same kind as a boundary, that is, a divide distinguishing the past from the future, and therefore, existing as the present instant.[7]

2.3 SB AND THE NOW

To relate this back to the central point of this chapter, the moving Now point makes sense of SB. As the Now moves, objects come into being. This does not mean in the sense of something existing in not being, and then entering into the "realm of being"; but in the sense of something beginning to exist. Thus, we can reconnect with the question of which sort of tense logic is preferrable: if becoming is part of the physical world, i.e., SB, and we can only count existing objects as the legitimate values of bound variables, then only present objects are the legitimate values of bound variables. Therefore, if becoming is part of the physical world, i.e., a P-tenser view of time, then the P-tenser view of logic seems preferrable.

All I have given so far is an explanation of what the P-tenser believes. Now we can ask whether becoming should be taken in its strong sense, i.e., SB, which is tantamount to whether a transient Now exists. To address this I will discuss modern theories of time and their relation to the transient Now.

---

[7] I mean here by "instant" what Miller means by "bare instant" (Miller, 134).

3 MODERN ACCOUNTS

Proponents of an Aristotelian view take SB and the transient Now as essential to an account of time; and any theory of time which does not account for it is deficient, as is any logic that does not account for it. To address the issues of tense logic, becoming, and the Now, then, we must address modern theories of time and their relation to the Now. For it is the lack of a developed account that gives the grounds for P-tensers to criticize such theories and the C-tensers to criticize P-tensers.

3.1 *PRIMA FACIE* EVIDENCE FOR THE TRANSIENT NOW

The most obvious motivation for including the notion of a transient Now is that it *seems* like we experience time's passing. Hans Reichenbach put it well when he noticed that "the feeling that *my* existence is a reality, while *Plato's* life merely still casts its shadows onto reality" and that we also feel "the compulsion which distinguishes for us a Now-point in an absolute way as the experience of the divide between past and future" (Grunbaum 1973, 315). The point is that in our experience the past had existence (but does no longer), the present has existence, and the future does not yet have existence (but will).

We can put things into sets which correspond to the three *degrees of reality*. I mean by *degrees of reality* three possible types of reality. Something has the highest grade of reality if it exists in the present; it has a different degree of reality if it has a causal effect on the present, but does not exist in the present; it has a different degree of reality, still, if it neither exists in the present, nor has a

causal effect on the present. These degrees correspond with the present, past, and future, respectively.

Things shift from one degree of reality to another. Again, let's take the example of the footprints in the sand. As the walker proceeds along the beach, from left to right, she brings footprints into existence. Let's take her creation of a particular footprint, say, the one directly in front of us, and call it *f*. If we call the set of objects which correspond with past, present, and future degrees of reality R_{pa}, R_{pr}, and R_{fu} respectively, we get the following shifting of the members between sets as she creates those footprints. When she was to the left, *f* was in the future: *f* was in R_{fu}. During *f*'s existence, *f* was becoming or had become. In other words, *f* was predicable of the Now, i.e., *f* moved from R_{fu} into R_{pr}. Currently, *f* is in the past: it has moved to R_{pa}. So, before that footprint was left, it was in the future; when it was being created it was in the present; and after it was destroyed it was in the past.

How do the degrees of reality connect with the notion of existence? The answer to this question depends on whether you are a P-tenser, or C-tenser or detenser. For the P-tenser, a transient Now is the point where different objects enter existence and/or leave existence. Time, then, flows along, giving being to things that correspond, for example, with our predictions. It is not as if the set R_{fu} actually exists, but we say in retrospect that certain things were going to come to be -- that footprint was going to be made. We can then put those things into R_{fu}: we do not put anything which "really" existed when we made the prediction, which we only come across as we proceed down the time axis -- the footprint did not exist only for the walker

and us to come upon it as we pass through time. For the P-tenser the members of R_{fu} possess no existence. Instead, they become as the Now moves. Moreover, the members of R_{pa} do not exist, either. For they have passed out of existence. Therefore, only the members of R_{pr} exist for the P-tenser.

For the C-tenser and the de-tenser, however, the members of all three sets have existence. The degrees of reality *merely* reflect our conscious awareness of things: R_{pr} objects are possible objects of our awareness; R_{pa} objects "cast their shadow" on our awareness, but cannot be objects of our awareness; and R_{fu} objects are not possible objects of our awareness. Nonetheless, they all exist.

Returning to the point of this section, P-tensers argue that our conscious experience provides support for the existence of the transient Now. And with no other good reasons, even the C-tensers and de-tensers agree that this is good evidence. However, the relationship between the Now and physical theories of time pose another set of issues: if the transient Now is not part of an accurate physical theory of time, then that may lend support to the view that the transient Now does not exist in the physical world. Instead, it may merely exist in conscious awareness. Therefore, we must now move beyond such *prima facie* evidence and ask the question of whether the transient Now plays a role in physical accounts of time.

3.2 MECHANICS AND A TRANSIENT NOW

It seems like a Now exists. But in this day where science often has the last word, what does science say? Is there a Now in the physical world according to physical mechanics? In this section I will

explain the accepted view. In short, while Newtonian mechanics did take into account the Now, SR does not account for the transient division of time between the past and the future. I will address each in turn.

3.2.1 NEWTONIAN MECHANICS AND THE NOW

Aristotle said that time is everywhere, suggesting a Now that is the same for all locations in space. Therefore, we can make sense of a notion of absolute simultaneity: two spatially separated objects can be considered simultaneous in an absolute sense. Newtonian mechanics utilizes such an absolute notion: Newtonian space spreads instantaneously and orthogonally with respect to the time axis. The transient Now makes time absolute in the sense that it is the same for all observers. Therefore, simultaneity at a distance makes sense. In other words, all objects simultaneous for one observer are simultaneous for all other observers. The same holds of successions. Newton did distinguish absolute simultaneity from observed simultaneity, which he called relative simultaneity. But he did not take the step which Einstein made famous, that is, he did not take relative simultaneity as basic to mechanics.

3.2.1 SR AND THE NOW

Many have held that Einstein's introduction of relative simultaneity denies a role for the absolute, transient Now. Relative simultaneity, it is argued, implies that the order of the occurrence of objects is relative to the observer. As we saw with Putnam's argument above, the transitivity of the existence relation implies that objects

in an observer's future exist for that observer. Let's take a closer look at this by considering Figure 2.2:

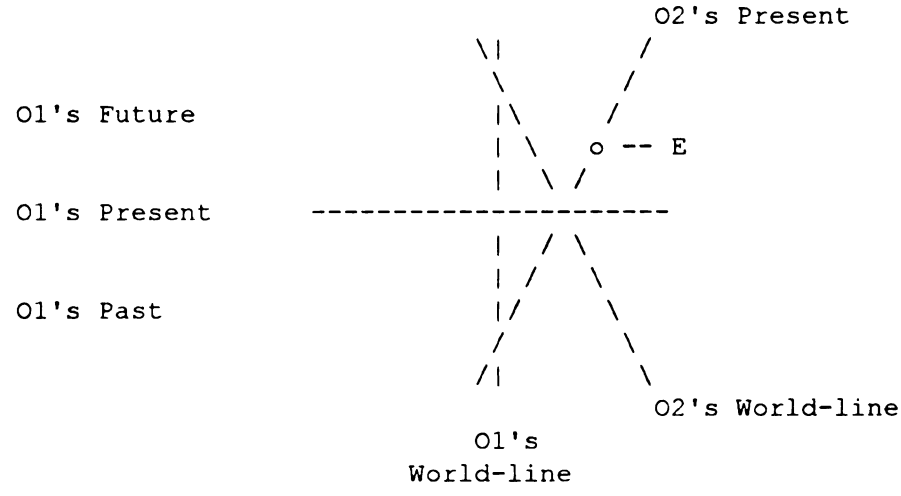


Figure 2.2

Putnam's argument works as follows. If the horizontal line is taken to represent O_1's present then O_2 is in O_1's present. If we take existence to be at the minimum that which exists at the present, then O_2 exists for O_1. Consider event E. E is in O_2's present; therefore, E exists for O_2. The relation "exists for" is transitive. I mean by this that if z exists for y, and y for x, then z exists for x.[8] However, E is in O_1's future. Therefore, since E exists for O_1, the future exists for O_1. Such reasoning can be applied to every event in O_1's future, and every event in every possible observer's future. Therefore, the future exists for all possible observers. Therefore, the future exists just as the present exists! Moreover, since nothing need be brought into existence, and since what is "now" for one observer may be in the future

---

[8] Putnam uses the relation "is real for" instead of "exists for", and argues that all that "exists for x" also stands in the relation "is real for" to x, e.g., if "y exists for x" then "y is real for x". I have use the notion of existence to maintain a consistent vocabulary with the appropriate changes in the example to maintain accuracy.

for another observer, a privileged Now does not exist either. Instead, the Now of the *here-now* in the Minkowski spacetime diagram merely designates an arbitrary origin of spatio-temporal coordinates (Grunbaum 1973, 318, and Putnam 1967, 240). For example, we can use the Minkowski diagram at noon on June 15, 1994 to let *here-now* designate a certain spatio-temporal point after the sun's extinction. The *absolute past* and *absolute future* are nothing more than the set of objects absolutely earlier and later than the object arbitrarily picked as the here-now, respectively. Relativity takes objects as simply existing, having reality, and having the relationships *earlier than* and *later than* the arbitrarily picked zero point. It does not account for a transient division of time into past and future by designating the moving Now of experienced time (Grunbaum 1973, 318).

4 SB AND PHYSICAL THEORY: CLASSIC ARGUMENTS

On the standard view, then, SR accounts for neither the transient Now nor SB. And given the success of SR without a transient Now, it would seem reasonable to conclude that the transient Now does not exist in the physical world. But is this the final word?

Sir Arthur Eddington argues that "[s]omething must be added to the geometrical conceptions comprised in Minkowski's world before it becomes a complete picture of the world as we know it" (Eddington 1963, 68). Without a transient Now, we simply have everything existing, including the future which we will come across. Max Black has referred to such representation as "a 'block universe,' composed of a timeless web of 'world-lines' in a four-dimensional space" (Black 1962, 181). The result, Black maintains, is 'the Eleatic view that nothing happens in

"the objective world'" (Black 1962, 181). Therefore, change becomes an illusion, something that has to be thrown out insofar as it includes the notion of coming into existence. Black obviously considers this a *reductio*. Of course, considering the neo-Eleatic view absurd does not make it so. Eddington clearly believes that physical mechanics is lacking an important ingredient. Therefore, both of these philosophers believe that there is more to be said.

In the following sections I will present two arguments for SB and neo-Eleatic objections. In section 4.1.1 I will explain the argument that a world which does not distinguish a direction to time is irrational and I will lay out objections in section 4.1.2. The second basic argument for SB is that quantum indeterminism implies SB. I will explain this argument in section 4.2.1, and objections to it in sections 4.2.2.

4.1 THE DIRECTION OF TIME

4.1.1 THE ARGUMENT

In arguing for SB Eddington suggests three things "we must note":

> (1) [Becoming] is vividly recognized by consciousness.
>
> (2) It is equally insisted on by our reasoning faculty which tells us that a reversal of the arrow [of time] would render the external world nonsensical.
>
> (3) It makes no appearance in physical science except in the study of organization of a number of individuals. Here the arrow indicates the direction of progressive increase of the random element (Eddington 1963, 69).[9]

[9] It should be noted that Eddington does not use "Becoming" but "Time's Arrow" in this passage. But for our purposes we can take them as being inextricably linked in that we notice Time's Arrow by consciously noting becoming. Moreover, if Time's Arrow reversed, we would have unbecoming.

(3) refers to Eddington's conviction, which he shares with Reichenbach, that entropy gives us SB, that is, a direction, arrow, or flow to time. Since a discusion of that issue would not contribute to my argument, I will not address it. However, since (1) and (2) are directly relevant to my argument, we will address them now.

Eddington, Black, Prior, Reichenbach, and G.J. Whitrow argue in the same vein, using (1) and (2). First of all, (1) alone does not give us warrant to necessitate SB's incorporation into a theory of time. For, as these philosophers recognize, arguing on the basis that something seems to be the case is poor philosophic and scientific practice. For example, we do not include our sensual experience of color (*qualia of the experience* as it is often called) in physical theory. We explain how it is caused in our minds -- light waves of certain wave-lengths impinge on our retinas sending electrical signals to our brains, etc. We rely on the notion of wave-lengths of light, not a physical description of our conscious experience of hues. Therefore, even if it seems that SB is a part of the world, there still must be more substantive reasons for including an account of it in a theory of time (Eddington 1963, 90; Reichenbach 1956, 17). Moreover, the fact that it seems that SB is part of the world only implies WB, not that SB is in fact the case.

Reichenbach and Eddington argue the world would be nonsensical without SB. And if it is an objective part of the world, then science would be justified, in fact obliged, to account for it (which they suggest can be done with the notion of entropy). An explanation of the

---

In other words, if Time's Arrow did not exist, there would be no becoming.

direction of time's arrow, (2), would facilitate an understanding of their position.

There is a *privileged directional* order to events in the world, as our footprint example demonstrates. The order plays itself out *dynamically* in the direction of causality: the dynamic element implies a certain direction in causality. But suppose this was not the case in the actual world. For example, suppose that the order of events in the footprint example did not correspond with the way we see it. Instead, the sequence of events was backwards. There would be two conceivable ways to account for the situation: (a) through reversed causality; or (b) teleologically, instead of causally.

Given our ideas about what causes are, *reversed* causality, (a), would require a redefinition of causality that would be too radical, in Reichenbach's view. For example, we could not account for the footprint's disappearance when the foot is picked up. Would we postulate an attractive force which pulled the sand with the sole of the foot, only to release when the sand that is being pulled by that mysterious force became level with the surrounding sand? What could the explanation be? Scientific notions are modified all of the time as scientist come across results at variance with our commonsense conception of things. However, an account which incorporates *reversed* causality would be an exceedingly radical modification of our current notion. The question becomes "would it be too radical?" Reichenbach *et al* would answer in the affirmative.

Reichenbach suggests that (b) would have to be the case: the footprints were there for the woman to step into so that they would disappear, or something like that. Surely this makes no sense either,

or it would have to be radically *ad hoc* (Reichenbach 1956, 153). So, the world must contain an objectively dynamic element: "'becoming' gives us a texture to the world which is illegitimate to reverse" (Eddington 1963, 94) and downright "implausible" to do without (Reichenbach 1956, 153).

The symmetry of the laws of relativity theory and all of physics do not seem to include such a dynamic process. Since SB is an essential part of the physical world, Reichenbach and Eddington conclude, it is impossible to give a complete account of the world without it. Since a theory is deficient if it does not account for an essential element of phenomena it is to explain and relativity theory does not account for SB, relativity theory is deficient. Therefore, Reichenbach and Eddington argue that it needs modification to account for the transient Now, SB, or the world's dynamic nature.

4.1.2 GRUNBAUM'S OBJECTION TO REICHENBACH AND EDDINGTON

Adolf Grunbaum agrees that the shifting division of the time continuum into past and future depends on the Now; and that Now is not furnished by the neo-Eleatic view of time purported to be a part of SR. But he holds, unlike those we have just looked at, for mere WB. He argues that since it contains irreducibly psychological features, the transient Now depends upon the existence of conscious awareness for its existence. In his view, the transient Now is merely our consciousness becoming aware of, or experiencing the "immediate effects [of an event], [and] we regard [the event, the objects of the event, and its effects] as 'taking place' or 'coming into being'" (Grunbaum 1973, 318). Moreover, he goes on to discount Reichenbach's criteria for

distinguishing the uniqueness of the Now, which is necessary for SB (Grunbaum 1973, 315). The first idea will be addressed presently. The second can only be addressed within the discussion of indeterminism in section 4.2.1.

Reichenbach argued that we can only make sense of an inanimate recorder if there is SB (Reichenbach 1956, 178ff). We will not rehearse his argument in detail. The gist of his argument is that it serves to explain why recording instruments record *only* present events. Now, if an inanimate recorder can record only present events, observing the recording would show the progression of SB. We don't really need a recording *machine*: the sand of the footprint example serves as a recording device, in its most basic sense. For the sand suffers (recognizable) effects from the woman's walking on it, and suffering effects just is what a recording devise does. Granted, only a conscious mind can interpret the footprints as being evidence of a human's recent promenade. But, the recorder, the sand, shows evidence of the SB of the event of the woman's walking (or of her individual sole striking against the sand).

The sand could not *record* the event at all without the notion of SB. For, to record simply means to add information which could be used to represent the occurence of an event to a system over time. It does not matter whether the information is perceived or not. The mere fact that there is a change from one point in the recording to the next indicates the dynamic process of SB.

Grunbaum points out that inanimate recorders show us only successions of events, not awareness of succession. If we were to examine the sand at different times, we would notice only the succession

of footprints. But no inanimate object, and surely not the sand, had awareness of the events which cause the footprints. Grunbaum argues that the problem for SB is that awareness is an essential ingredient of the meaning of *Now*, for "the now-content, when viewed as such in awareness, includes an awareness of the order of succession of events in which the occurrence of that awareness constitutes a *distinguished element*" (Grunbaum 1973, 325). The uniqueness of the Now is defined by our awareness of it. Moreover, "[b]ecause of its inherent dependence on consciousness, the transiency of the now is not also a feature of physical time" (Grunbaum 1973, 316).

Grunbaum makes this point with the following passage:

> there is a *diversity* of the Now-contents of immediate awareness. Hence it is a matter of fact that the Now "shifts" in conscious awareness to the extent that there is a diversity of now-contents, and it is likewise a fact that the Now-contents are temporally *ordered*. But since these diverse Now-contents are ordered with respect to the relation "earlier than" no less than with respect to its converse "later than," it is a mere *tautology* to say that the Now shifts *from* earlier *to* later. For this metaphorical affirmation of shifting *in the future direction along the time-axis* tells us no more than that later Nows are later than earlier ones and [vice versa] ... (Grunbaum 1973, 315-16, author's italics).

He means by "diversity of the Now-contents of immediate awareness" that at different points along the time-axis conscious beings have different sets of contents present to their awareness. For instance, at this instant you have, among other things, the now-content of reading the words on this page, the awareness of various sounds, etc. At each successive point along the time-axis, those now-contents change. So, to express different moments in time and take these changing now-contents into account, all we need to do is include the now-contents at those

moments. Therefore, certain past now-contents are earlier than present now-contents, future now-contents are later than present now-contents, etc. Now we can see the import of his claim that to say that the Now shifts from earlier to later is a mere tautology: in a more general form, that is exactly what it means to say that the Now moves along the time-axis of a Minkowskian diagram.

Grunbaum argues that if this view is correct, then the only thing that could save the proponents of SB is to describe a set of criteria for distinguishing a Now point which does not rely on psychological features. They fail to do so. Therefore, without further argument there is no good reason to include becoming in the physical world. The proponents of SB provide a second argument which I will turn to next.

4.2 INDETERMINISM AND SB

Reichenbach, Eddington, Whitrow and the astronomer Bondi, and more recently, Stein and Dieks all argue that indeterminism is a necessary and sufficient condition for SB. Grunbaum and Sellars deny that indeterminism implies SB. As we just saw, they argue that the existence of the transient Now, or SB, is merely our becoming aware of changes in objects as we enter into the absolute future of particular events. So, the determinism/indeterminism debate has no bearing on this issue: indeterminism does not insure SB (Grunbaum 1973, 321; Sellars 1962, 599ff.). In section 4.2.1 I will present the argument from indeterminism for SB presented by Reichenbach *et al*; In section 4.2.2, I will turn to Grunbaum and Sellars to give a more detailed account of their objection to this argument.

4.2.1 INDETERMINISM

The proponents of SB argue that due to the indeterministic nature of the quantum world, until something becomes, it is not. For, in no way can we say that something is going to happen -- there is always the chance that it may not. To make this point in a very awkward and obviously imprecise way, nothing was going to happen until after the fact that it has happened. Only when it happens can it become, and only when it becomes can we say that it was going to happen. To put it yet another way, the relations between the members of the sets of objects of two world states, that is, the sets of objects of the world at different times, are not linked in the one-to-one function necessary for a deterministic conception of the world. And without a one-to-one function, some objects are not implied by the previous state. Only after they have become does it make sense to say that they were going to be. So, SB is an essential ingredient to understanding the physical world as it exists at any particular time.

As Eddington put it:

> The division into past and future (a feature of time-order which has no analogy in space-order) is closely associated with our ideas of causation and free-will. In a perfectly determinate scheme the past and future may be regarded as lying mapped out--as much available to present exploration as the distant parts of space. Events do not happen; they are just there, and we come across them. "The formality of taking place" is merely the indication that the observer has on his voyage of exploration passed into the absolute future of the event in question; and it has no important significance (Eddington 1921, 551).

SB, for them, must include indeterminism. For, determinism implies that future events exist, in some sense, already. They are at least not going to come into being, which characterizes SB.

4.2.2 A UNIQUE NOW

It may seem at first glance that this argument gives rise to a set of criteria to distinguish a unique Now point, thus overcoming the objection in section 4.1.2. The privileged Now is distinguished from other Nows by its determinate past and its unpredictable future. We can figure out which Now is privileged by noting what parts of history are already determinate and which are indeterminate. Our past is always determinate and our future is indeterminate (given indeterminism). Moreover, we can look to any time in the past and see what happened in its absolute future (until the present). Therefore, those Now points cannot be privileged. As for possible future Now points, their pasts are not completely determinate. Therefore, only the current Now point has a completely determinate past and an indeterminate future.

4.2.3 NOW UNIQUE NOW

But here Grunbaum and Sellars find a weakness in the argument. They notice that these criteria are *still inadequate* to define a *unique* Now. The criteria hold for any state of the physical system and its absolute future regardless of the time of the physical state:

> ... if we consider *any one* of the temporally successive regions of space-time, we can assert the following: the events belonging to its particular absolute past could be (more or less) uniquely specified in records which are a part of that region, whereas its particular absolute future is thence quantum mechanically unpredictable. Accordingly, every "now," be it the "now" of Plato's birth or that of Reichenbach's, always constitutes a divide in Reichenbach's sense between its own recordable past and its unpredictable future, thereby satisfying Reichenbach's definition of the "present" (Grunbaum 1973, 322).

Briefly restated, the records of any time *t* point to a unique history while the absolute future is still underdetermined. But any *t* will do, i.e., any *t* would fulfill Reichenbach's and Eddington's criteria for being a privileged Now point. Therefore, although there is a unique past and future for every Now, there is no unique Now. Moreover, without a unique Now, there is no SB, for all just is.

Grunbaum's and Sellars's criticism of Reichenbach's and Eddington's criteria for distinguishing a unique Now may not seem damaging when looked at in the following way. Grunbaum and Sellars are arguing that because there are no criteria for defining a unique Now, the indeterminism debate makes no difference. But they imply from this that the universe must be static. They are claiming that because we cannot yet define a Now, it must not exist. However, Grunbaum's demonstration that another set of criteria, one that does provide the needed element, could not be devised relies on his psychological interpretation of the Now; later I will show that this is suspect, at best.

Nonetheless, Grunbaum's criticism points to a serious problem for proponents of SB: an adequate definition of a absolute Now needs to be constructed. Reichenbach himself agrees that a definition of a privileged Now is needed to make the notion of SB tenable. It is in part for this reason that I have chosen to highlight these arguments. There are other arguments for SB, for example, arguments from entropy. I have chosen not to address them here as they will not add anything to the explanation of my argument for SB below. The arguments that I have chosen, however, give the context within which I must present my argument for SB. I will show that SB is *not excluded* by SR, as the

Putnamean argument suggests. Moreover, I will define the transient Now. Let's turn to those arguments.

5 SR IMPLIES AN OBJECTIVE TEMPORAL ORDER

I will argue with Capek that, despite the common account, SR does make sense of the transient Now.[10] Then, I will characterize the resulting Now. To foreshadow that discussion, the new Now is not absolute in that it is everywhere. This makes it different from the Aristotelian Now. However, Capek's Now is absolute in the following sense: *certain successions must proceed in a certain order regardless of the reference frame chosen.* In other words, relative simultaneity does not imply that all successions are relative to an observer, for some must hold for all possible observers.

5.1 CAPEK'S ARGUMENT

Capek shows that objectively-ordered successions are the legacy of Minkowski's formula for the world interval (Capek 1976, 508; 1991, 324).[11] The spatial and temporal intervals separating two events E_1 and E_2 are separately invariant for each inertial frame s, where:

(i) $s = [(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]^{1/2}$, where x_1, y_1, z_1, x_2, y_2, and z_2 are the spatial coordinates of E_1 and E_2, respectively;

(ii) both s and $(t_2 - t_1)$ are constant, where t_1 and t_2 are the temporal coordinates of E_1 and E_2, respectively.

---

[10] Quentin Smith offers further arguments against Grunbaum's position by pointing out that big ban cosmology only makes sense given the notion of a present now. For it starts all of its equations from a present now. Moreover, it makes sense of a now *prior* to any conscious beings' existence (Smith, 114).

[11] I will refer only to Capek's 1976 article. But an equivalent reformulation can be found in his 1991 book.

Constancy is a characteristic of the world interval, defined as:

$$I = s^2 - c^2 (t_2 - t_1)^2 = \text{const } (c = 3 \times 10^{10} \text{ cm/sec}).$$

The formula for I shows how classical and relativistic mechanics are different. In relativity theory constancy does not belong to the spatial and temporal interval separately as it does in classical mechanics. Instead, it belongs to them as connected to each other.

We can classify any pair of events E_1 and E_2 according to whether the value of the World Interval separating them is positive, zero, or negative. The relationships correspond to, respectively, E_2's being outside of E_1's forward light-cone, E_2's being on the boundary of E_1's forward light-cone, and E_2's being within E_1's forward light-cone (see Figures 2.3, 2.4, and 2.5). I will address each grouping in turn.

5.1.1 A POSITIVE WORLD INTERVAL

In the first case, where the World Interval is positive, the square of the spatial distance separating E_1 and E_2 is greater than the square of the speed of light multiplied by the square of the temporal interval separating E_1 and E_2, that is, $s^2 > c^2(t_2 - t_1)^2$. E_2 is outside of E_1's forward light-cone (see Figure 2.3). Therefore, the spatial separation is greater than the distance which the fastest causal signal, electromagnetic radiation, could cover in the requisite time. It can be shown that the order of such events is relative to the observer. This, then, is the case on which the neo-Eleatics rely.

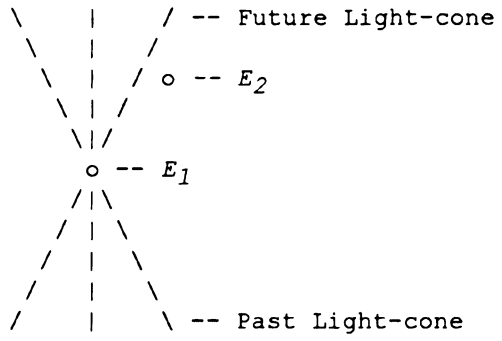


Figure 2.3: E_2 is outside of E_1's forward and rearward light-cones

5.1.2 A WORLD INTERVAL OF ZERO

However, the other two cases provide *objective* time orderings, to which the proponent of flowing time can look. In the case where the World Interval equals zero, that is, $s^2 = c^2(t_2 - t_1)^2$, the square of the spatial distance would be equal to the square of the velocity of light multiplied by the square of the time interval. E_2 is on the boundary of E_1's forward light-cone (see Figure 2.4). Only objects traveling the speed of light relative to E_1 fit this formula, unless the time interval became zero. But in that case the spatial separation would also become zero, so E_1 and E_2 would merge to become the same event. But this would be absurd unless they truly were the same event, leaving it impossible that they could ever be viewed as two separate events. Therefore, two distinct events, one on the boundary of the other's future light-cone can never be seen as simultaneous, *by any observer*. Since they can never become simultaneous for any observer, they cannot reverse their order for any observer, either. Here is our first instance of an objective order in SR.

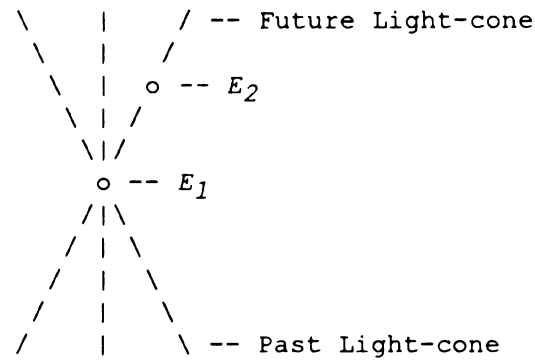


Figure 2.4: E_2 is on the boundary of E_1's forward light-cone

5.1.3 A NEGATIVE WORLD INTERVAL

The third case is where the World Interval is less than zero, $s^2 < c^2(t_2 - t_1)^2$. The spatial distance, then, is smaller than the distance covered by electromagnetic radiation, given the time interval. In other words, E_2 is within E_1's forward light-cone (see Figure 2.5). Mechanical causation becomes a possibility. In this case, instead of the spatial interval vanishing along with the temporal interval, the value of the spatial interval would become imaginary, that is, if the time of event E_1 was identical to that of E_2, then $s^2 < 0$. Therefore, two distinct events, where one is within the other's future light-cone, can never be seen as simultaneous, thus never in reversed order, by any observer. As Capek points out, this case is the generalization of the second case, for "the succession of causally related events, whether they are joined by the world lines of photons or by those of material particles, is a topological invariant independent of our choice of system of reference" (Capek 1976, 510).

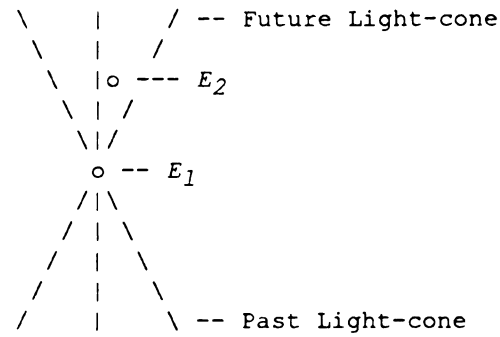


Figure 2.5: E_2 is within E_1's forward light-cone

5.2 THE FUTURE'S EXISTENCE

In this section I want to explain why I agree with Capek's conclusion. However, it is for slightly different reasons than his. So, I will briefly lay out Capek's argument, show why I believe that it begs the question, and then show why I believe that the objection is surmountable.

5.2.1 CAPEK

5.2.1.1 CAPEK'S ARGUMENT

Capek argues for the reintroduction of the transient Now based solely on the objective time ordering of causally related events (Capek 1976, 519). Nothing in the causal future of an individual, a, can be in a's causal past for any observer. With no possible observer, there is no need to postulate the future's existence. Therefore, it becomes plausible to maintain that a transient Now which roughly corresponds with a's experience is the point where the future comes into existence for every possible observer, as well as for a.

5.2.1.2 BEGGING THE QUESTION

The first possible objection is that some equations which fit SR would affirm the possibility of observers from a's causal future who could see things in a temporally reversed order from a. But that would rely on one of two assumptions: (1) actions either moving backward in time or (2) moving faster than the speed of light (Capek 1976, 519). Adhering to (1) could only come about by accepting imaginary values for spatial distances (something which seems unexplainable, at least in realist terms); adhering to (2) could only come about by denying the basic assumptions of SR. Thus, Capek has limited the observers of which he speaks to *possible* observers.

Capek's position, however, relies on the assumption that future events are unobservable in principle, which follows from two further assumptions: (1) observables must be in the present or causal past of an observer; and (2) according to Minkowski's formula, no possible observer's causal past can *now* be in another's causal future. To postulate the existence of future events one would either (a) have to claim that they are observable by an observer in another reference frame, or (b) have to admit their intrinsic unobservability. According to Capek, (a) contradicts SR, something the neo-Eleatics do not want to do. (b) contradicts accepted philosophical and scientific practice. So, postulating the existence of future events is akin to postulating phlogiston, caloricum, the ether, and other discredited entities (Capek 1976, 520).

However, Capek has begged the question. Surely, one might say, there are here-nows from which a's future is observable, namely, those

in a's future light-cone.[12] So, there are possible observers who, in principle, can observe a's future. In other words, one might object to (1). To draw the conclusion which Capek desires, one would have to assume a meaning of *observable* which includes some notion of the present, call this the *strong sense of observable*. The strong sense of the term, however, begs the question.

Future events are observable in a weaker sense: a future possible observer could observe them. So, they are observable in principle. This is the more common usage of "observable". Moreover, it does not beg any questions. However, it does not do the work which Capek desires.

This objection has even deeper roots expressible in terms which Grunbaum has used in discussions addressed in previous sections of this essay. Grunbaum has pointed out that dynamic theorists have failed to define a privileged here-now which has the unique quality of "presentness" (Grunbaum 1973, 322). Since there is no unique here-now, all here-nows must have the same ontological status. Capek has done the same thing as the dynamic theorists. Since his notion of observability begs the question, he has no way of distinguishing a unique here-now. So, there is no way of saying that future here-nows do not exist, or at least exist differently than the present one exists.

5.2.2 SR NEUTRALITY

Capek's argument, although it does not show that SR implies a transient Now, suggests that SR is *neutral* on the issue: to conclude either way would take more argument than SR provides. Based on

---

[12] Thank's to Dr. Richard Hall for pointing out this glaring problem.

Minkowski's formula for the world interval, there are objective time orderings. But it is only from the relativity of simultaneity, such as that which occurs in the first grouping above, that many have provided support for the view that time is static, that the dynamic passage of time is an illusion. However, the absolute nature of objective time orderings in the second and third cases undermines the force of the implication to a neo-Eleatic theory of time. With such a result, and in the absence of any other arguments in favor of a static conception, we must at the least remain neutral concerning the existence of the future. Therefore, in the absence of further argument both the neo-Eleatic and the dynamic theorist must beg the question to conclude either way about the existence of a transient Now or about the existence of the future. I want, then, to consider possible arguments to recommend each view.

5.2.3 MINKOWSKI DIAGRAMS AND NEO-ELEATICS

First of all, are there any other grounds for implying a neo-Eleatic conception of time? Some have argued that the block-universe representation of Minkowski spacetime diagrams suggests the existence of the future, independent of relative simultaneity. However, it seems to me that the ability to construct that particular sort of diagram does not imply anything about the future's ontological status. The same type of diagram can be drawn with a Newtonian conception of space and time. As Massey has pointed out, the suggestion that SR implies Eleatic time based on the Minkowski diagram would also imply that Newtonian time is Eleatic (Massey 1969, 19). But no one, as far as I know, has suggested that the Newtonian conception of time is Eleatic.

Moreover, Reichenbach has pointed out that neo-Eleatics have argued from the desire for a static universe to the existence of one, much like Zeno tried to vindicate Parmenides: they come up with all sorts of quasi-scientific and quasi-mathematical constructs to vindicate the supposed result from SR (Reichenbach 1956, 9). Capek has shown that SR does not imply a "real" block universe. Therefore, one would have to beg the question by assuming the "real" block universe to prove that it existed, and then only through amazing constructs.

There is more to discount the neo-Eleatic position. If the neo-Eleatics expect to maintain that time does not pass, they have to explain how it is that "[the passage of time] is vividly recognized by consciousness" (Eddington 1963, 69). They argue that the transient Now depends upon conscious awareness for its existence. According to this view, the transient Now is merely our consciousness becoming aware of, or experiencing the "immediate effects [of an event], [and] we regard [the event and its effects] as 'taking place' or 'coming into being'" (Grunbaum 1973, 318).

But the neo-Eleatics have no grounds for arguing that the transient Now is merely psychological. In fact, to do so would be to introduce undue complications. For they would have to explain the dynamic relationship between a static universe and a dynamic consciousness, which is doubly problematic. First, assuming a physical representation of consciousness, they must explain how part of a static system can dynamically represent the world. Second, the relationship itself would seem to be dynamic.

Massey's article suggests to me another point: the difference between neo-Eleatics and dynamic theorists is a paradigmatic difference,

in a *quasi*-Kuhnian sense. Their differences stem from their background beliefs about time. However, unlike other Kuhnian disputes, there are trans-paradigmatic reasons for favoring one theory over the other. First of all, the reasons for favoring a neo-Eleatic theory of time based on SR seem to fail. So the background beliefs in a neo-Eleatic theory are unsupportable from within the paradigm. Secondly, as I just argued, a static theory of time imposes incredible requirements on the explanation of the connection between the mind and the "real" world.

5.2.4 EMPIRICAL EVIDENCE, SIMPLICITY AND THE TRANSIENT NOW

5.2.4.1 MY ARGUMENT

Based on empirical evidence, I will conclude that time is dynamic. Put simply (and seemingly naively), it seems like time passes! Since SR does not by itself (or without begging the question) inform us on the issue, and we have no other good reasons to believe otherwise, we should simply accept that the future does not exist! It seems to me, then, tenable to hold with Capek that "[the] physical here-now corresponds roughly to my psychological awareness of the present, precedes all events of my causal future and follows all events contained in the backward cone of my causal past" (Capek 1976, 518). Clearly, such seemings are consistent with WB. However, I am not suggesting that we should adhere to SB *merely* on those grounds. In the absense of arguments to the contrary, however, we should.

5.2.4.2 OBJECTIONS AND REPLIES

Some may object that seemings, on which my argument relies, are not adequate to solve such an important topic. I would agree, in the face of some forceful objection to the seemings. To determine the ontological status of something we should look to scientific theory and philosophical argumentation, where it informs us. However, when it does not inform us, we look to intuitive experience. At least in relation to SR, that is what must be done here.

Another possible objection is that the experience of time is analogous to the experience of colors: the mind merely represents time as dynamic, although the physical counterpart is fundamentally different. There are two replies to this objection. First, physical representations of colors do not include any element of the psychological quality of color. So far as I know, there is no analogous situation in time: all explanations of the physical counterpart to our experience of a dynamic quality of time include the dynamic quality. For example, thermodynamic accounts of time's passage just are accounts of a dynamic component in physical time. No separate psychological component is necessary.

The second reply to this objection is based on the first reply and refers us above to the discussion about the neo-Eleatic theory. Since the dynamic quality of time can be accounted for in the physical world, there is no need to explain why we experience it as such. This is disanalogous to the case in explaining our conscious experience of colors. Therefore, as I said above, to add the dynamic *experience* of time to the list of the problems in the philosophy of mind which need to be solved seems unnecessarily complicating. Simplicity is valued in

theory choice. Dynamic theories of time are simpler in this respect than neo-Eleatic theories.

5.3 A NEW TRANSIENT NOW

As I mentioned above, a new transient Now results from Capek's argument. In distinguishing time and change Aristotle said that time is everywhere, while change is not. Therefore, the Aristotelian Now is present everywhere in the universe -- thus the notion of absolute simultaneity. But, the Now of SR is confined locally in that it offers a division between the future and past light-cones of particular events.

Consider the Minkowski diagram again, as depicted in Figure 2.6:

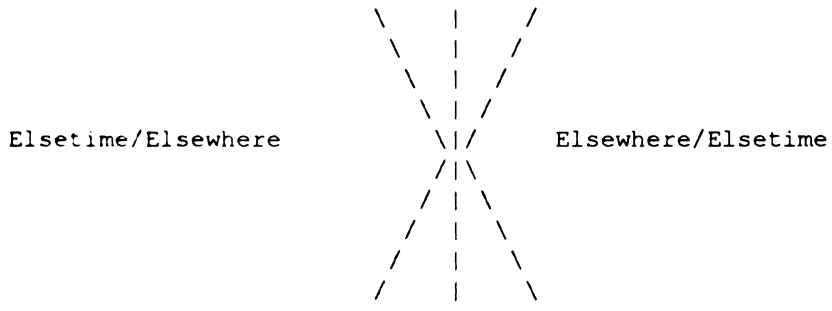


Figure 2.6

Everything outside of an enertial frame's future and past light-cones is topologically simultaneous, that is, all of those objects are simultaneous relative to an observer in that enertial frame. Things in the elsewhere regions are by definition unobservable since they are located such that no physical signal can reach the observer at that now. The existence of such things is assumed or stipulated. However, stipulation cannot establish the existence of such things. In fact, *nothing* beyond the here-now can be established as existing. Being good

verificationists requires that we conclude that there is no verifiable existence at the present, therefore, no present existence outside of the here-now.[13]

Consider the following example. Taking the arbitrary origin as the time when I am writing this, the Minkowski diagram designates the Now at a particular point along *my* world line, the here-now. We have no way of equating it with the here-now of your world line at the time which I am writing this. Therefore, the "[here-now] is not absolute in the classical Newtonian sense since it is confined to 'here' and does not spread instantaneously over the whole universe" (Capek 1976, 519).

Nonetheless, the now maintains its objective status in that it distinguishes an objective order of some observable events, for any possible observer. It is absolute in that it distinguishes the order in which the events *must take place regardless of observer's frame of reference*. The here-now is not relative in all respects. So, in this sense it similar to the Aristotelian Now.

To summarize, the here-now of SR is not absolute in that it is defined locally. However, the now is absolute in that no observation can be made of anything in its future light-cone, regardless of the frame of reference. So, the future does not exist for us to come across. O+ur move to the here-now might be considered like moves to non-Euclidean geometries in the last century. In this vein, we might consider the Newtonian Now as a special case of a more general flow of time, much like Euclidean geometry is a special case of a more general geometry. Thus, to deny the possibility of a more general flow of time

---

[13] For a similar, if not identical argument, see Capek 1976 and 1991. I rely heavily on his presentation.

simply because the Aristotelian Now does not adequately represent the physical world would be like denying the possibility of any geometry simply because Euclidean geometry does not accurately represent the physical world. SR does not deny the existence of the Now. In fact, it implies the here-now, or maybe more accurately, the *now-here* as space has been temporalized by this move.

6 CONCLUSION

In this chapter I have explained the basis for the difference between C-tensers and de-tensers on the one hand, and P-tensers on the other. P-tensers argue from the perspective of those who believe that the Aristotelian Now must be part of the Physical world. One of those perspectives, the Reichenbachean, argues that the succession of events in the physical world implies a particular order of events. To deny that order would be nonsensical. I believe that Reichenbach was correct on this count.

However, Grunbaum pointed out that Reichenbach failed to define a unique Now for the physical world. Thus, Grunbaum argued, Reichenbach failed and becoming is merely psychological. Such a position rests on the belief that relativity implies a complete relativization of temporal relations. However, relativity implies the *objectivity* of the order of succession of events about which Reichenbach speaks. Capek argues correctly that all causally connected events must be viewed in the same order by all possible observers. Therefore, to hold a neo-Eleatic view of the universe against relativity would be also contrary to accepted scientific practice.

Thus, while Capek's argument begs the question, it does show that SR is neutral concerning the transient Now. However, such a Now is different from the Aristotelean version. The Now is not definable as instantaneously present across the universe. It is defined in respect to a reference frame. However, it maintains a split between future and past that no observer can overcome. So, events in the causal future of a particular here-now must be in the future of all here-nows.

If my account is correct, then the P-tenser may be a preferrable position for a tense logician. In the next chapter I will discuss the implications of this view for the P-tenser. In particular, I explain the basic P-tense logic QQK_t and the limitations put on it by the results in this chapter.

CHAPTER 3

THE P-TENSER APPROACH TO TENSE LOGIC

1 INTRODUCTION

In Chapter 2 I argued that a dynamic theory of time is preferable, from a metaphysical point of view, to a Neo-Eleatic view of time. I showed that the transient Now of passing time is consistent with special relativity (SR), contrary to popular accounts. Therefore, on special relativistic grounds there is no good reason to deny that all existence is confined to the present. Moreover, if we accept the principle that only existing things can be the values of bound variables, then given the above assumption we can only treat present existents as possible values of bound variables.

In this chapter I will present a reconstruction of QQK_t, a quantified version of Prior's tense logic system QK_t. It provides a system which is metaphysically pleasing to the dynamic theorist, albeit at the cost of denying powerful and generally accepted logical relationships. I will critically evaluate QQK_t in Chapter 4.

Before we move on, however, some notation needs explanation. For the discussions which follow, take "-", "→", "&", and "v" as the standard negation, conditional, conjunction, and disjunction connectives, and "P" to mean "It was the case that" and "F" to mean "It will be the case that". I will use the following metalinguistic

symbols: "A", "B", and "C" with or without subscripts as variables for formulas, "s" with or without subscripts as sentence letters, "Q", "R", and "S" with or without subscripts as predicate letters, and "v" with or without subscripts as individual variables. I will use the following in the object languages: "p", "q", and "r" with or without subscripts for sentence letters, "M", "N", and "O" with or without subscripts for n-place predicate letters, and "x", "y", and "z" with or without subscripts for individual variables. Much of this will be repeated in the formal presentations of QK_t and QQK_t.

2 PAST TENSED CONNECTIVE AND ILLICIT CONDITIONALS

In this section the logical relationship between the well-formed formulas (wffs) "-PA" and "P-A" will be examined. In particular, consider the following wff:

C1 P-A → -PA

C2 -PA → P-A.

Typically, C1 is denied, while C2 is taken to be logically true. However, Prior denies both. After a brief account of C1 and C2 as they are interpreted in the minimal tense logic K_t, I will discuss the reasons that led to Prior's rejection of the typical account.

2.1 THE DIFFERENCE BETWEEN "P-A" AND "-PA"

The following are not rigorous proofs of the logical relationships between "P-A" and "-PA", but merely intuitive accounts of what is

normally accepted.[14] Take the utterance "Andrew was not married", referring to my friend Andrew, uttered after he had been married for some time. The situation could be diagramed as in Figure 3.1.

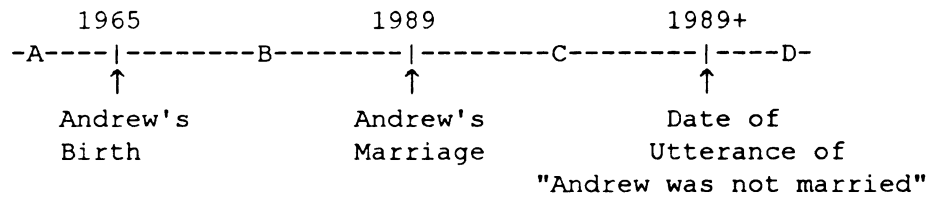


Figure 3.1

The portion of the diagram labeled "A" is the time before Andrew was born; the portion labeled "B" is after his being born, but before being married, that is, when he was unmarried and alive; C is after his marriage, but before the utterance; D is after the utterance.

Let "p" stand for "Andrew is married" and consider two possible translations of "Andrew was not married":

TP1 P-p = "It *was* the case that it is not the case that Andrew is married";

TP2 -Pp = "It is not the case that it *was* the case that Andrew is married".

If the speaker meant to utter a true sentence, TP2 would be an incorrect translation. According to the diagram Andrew was married at some time in the past. Therefore, "It was the case that Andrew is married" is true, i.e., Pp. If "Pp" is true, then "-Pp" must be false. On the other hand, TP1, "P-p", would be the translation of a true sentence, for at some time in the past, e.g., some time in area B, "Andrew is not

---

[14] I have chosen to present these relationships this way since there are plenty of authors supporting this claim. See for example, Prior 1968, 151ff. See also, Williams, 132ff.

married", "-p", would be true. Thus, Andrew was not married at some time in the past, P-p. Since, "P-p" could be true, while "-Pp" is false, the conditional C1 can be false.

On the other hand, normally the conditional C2, "-PA → P-A", is taken to be logically true. Assume that C2 can be false:

(1) "-PA" is true at time t, and

(2) "P-A" is false at t.

From (1), "PA" is false at t. Thus, "A" is not true at any time before t. Therefore, "-A" is true for all times before t. From (2), "-A" was never true before t. Thus we get a contradiction. Therefore, C2 is logically true.

2.2 PRIOR DISAGREES

Prior argues that C2 is illicit. Clearly, it would have been false at all times before his birth that "Andrew is married", however, not because "Andrew was not married" was true, but because there would have been no facts about Andrew at all. *So no one could have said truthfully of him either that he was married or that he was not married.*

This conclusion falls from Prior's discussion of what he calls the "self-contradictory" statement "I do not exist" (Prior 1967, 150-151). No one could say "I don't exist" and utter a truth. However, one could say "One hundred and ninety-two years ago I didn't exist". This is commonly taken to be an example of a past-tensed connective "wrapped around" a tenseness sentence: "It was the case one-hundred and ninety-two years ago that I don't exist". But Prior claims that since the sentence "I don't exist" is self-contradictory it could not say

something true. However, the translation claims that the sentence "I don't exist" could have been true at some point, which is clearly not the case.

Prior takes this as an argument about facts:

> It is clear from this that if someone says *truly* 'I didn't exist at t_1', the truth of this cannot consist in there having been a fact at t_1, which someone could have expressed by then saying 'This doesn't exist', since that is *always* 'self-contradictory' (Prior 1967, 151).

He means that the sentence must always be false. He does not merely argue that the "self-contradictory" nature of such sentences implies that there are no facts to which they refer. He argues that when things do not exist one cannot speak of them, or, more accurately, one cannot predicate, truly or falsely, anything of an object that does not exist at the time of which one speaks.

Applying this line of thinking to C2 it becomes clearer why he thinks that C2 fails. Take the example similar to the one represented in Figure 3.1. Suppose now that "Andrew was not married" is uttered at Andrew's birth. Figure 3.2 can be used to represent such a situation. Figure 3.2 only needs two areas: A' for before Andrew birth and the utterance of "Andrew was not married", and B' for after Andrew's birth and the utterance of "Andrew was not married".

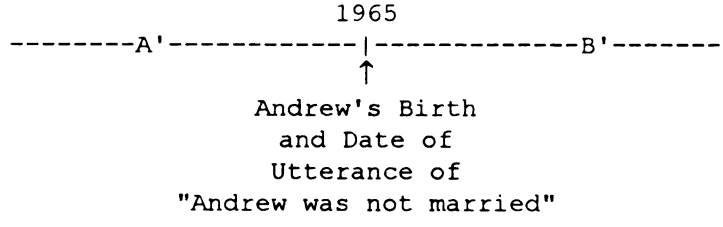


Figure 3.2

Clearly it would be false that Andrew is married during A'. It is also false that Andrew was unmarried during A'. For there were no facts about Andrew in area A'. If "p" represents "Andrew is married", then both "p" and "-p" are false in area A'. Thus, both "Pp" and "P-p" are false at the time of the utterance of "Andrew was not married". Moreover, "-Pp" is true, since it was not the case that "p" was true, i.e., "Pp" is false. Thus, Prior concludes, C2, "PA → P-A", does not hold.

So what went wrong in arguing that C2 was logically true, in Prior's eyes? The step above where I inferred that the negation of a wff must be true from the lack of the wff's truth does not hold. Above I wrote: "...'A' is not true at any time before t. Therefore, '-A' is true for all times before t". This is an illicit inference. Neither a statement which has nonreferring subjects nor its negation are true since there are no facts about nonreferring subjects. Thus, "-A" needn't be true simply because "A" is not true. This is not to say that Prior denies the law of excluded middle: he does not hold that a wff and its negation can both be true. He only maintains that neither need be true. Therefore, whatever system Prior comes up with it will have to accommodate such fine distinctions in order to provide a counterexample to C2.

2.3 C.J.F. WILLIAMS'S OBJECTION

On the whole, I believe that Prior is correct. If we accept a tensed view of time, and if we want our logic to reflect a metaphysically responsible view of time and the universe, then we must accept the view that conditionals such as C2 do not hold. But those

conditionals are used in English, as C.J.F. Williams points out (Williams 1981, 132). Moreover, Williams charges Prior with taking "P-p" and "-Pp" as representing propositions about sentences, instead of about what "p" is about. In this section I will review these objections and conclude that they are the result of an unfortunate use of terms by Prior; but I will disagree with Williams's charge that Prior was incorrect.

2.3.1 WILLIAMS'S CHARGE

Williams argues that Prior's account results from mistakenly arguing that because something could not be said at a certain time, it could not have been true at that time. Williams means by "could not be said" that that sentence can not be uttered and that it mean the same thing it would mean if the subject existed at that time. For example, if 30 years ago my grandfather had said, "My grandson will write of me some day", it would not have meant the same thing as it would have meant, say, four years ago. The reason is that 30 years ago I was not yet born, and thus the words "My grandson", uttered by my grandfather, would not have had a referent as they did four years ago. With that qualification in mind, let's take another example.

In English we could imagine a context in which we asked if (my friend) Andrew was married two-hundred years ago. If, for instance, someone did not know who Andrew was and thought that we were discussing the American Revolution, one could mistakenly ask if Andrew was married then. Williams charges that Prior would insist that we answer "no" on the grounds that no one could have uttered the sentence "Andrew is married" at the time of which we are speaking. But in actual

conversation we would probably answer that Andrew was not yet born, or that the question was ill-conceived, or we would make some other point which does not merely give a negative answer. Moreover, Prior's negative answer would suggest that "Andrew was unmarried" would be true, contrary to his position that it is false. Since Prior's account conflicts with actual usage, Williams concludes, Prior must be mistaken.

Williams tries to explain the mistake by arguing that Prior is saying that since we cannot say something at a certain time, it is false (no one could have said two-hundred years ago either "Andrew is married" or "Andrew is unmarried" and either be true). And this, Williams goes on, is beside the point. Surely we could not have said those things, but that does not make them false now (Williams 1981, 133).

Williams draws a distinction between either "speaking about the sentence and saying what it could or could not have been used to say; or ... using the sentence in an attempt to describe..." Andrew's marital state two-hundred years ago (Williams 1981, 133). The former, Prior's alleged attempt, suggests that he is arguing that the sentence could not have been used to say something true two-hundred years ago. However, the latter option, what Prior claimed to attempt, is that we could not say something about Andrew's marital state two-hundred years ago, that is, timeless propositions about Andrew's marital state did not exist then. So, although Prior claims to be arguing about states of affairs, i.e., propositions, Williams claims that he is arguing about sentences.

2.4 ON BEHALF OF PRIOR

However, it seems to me that Williams ignores a serious point about Prior's project. Surely Williams is correct about English usage

and what we mean. But does Prior really miss the boat here? Prior agrees that in ordinary conversation sentences like either "Andrew was married two-hundred years ago" or "Andrew was unmarried two-hundred years ago" express nontruths. But he says neither that we would nor that we should leave it at that in actual conversation. He is simply making a point about the truth or falsity of what these sentences express, which are neither true nor false if their subjects does not exist. Recall that Prior denies that he is constructing a logic about English usage. Instead, he is constructing a logic about the metaphysics of temporal ontology (Øhrstrøm & Hasle 1993, 31).

Williams's second point is that Prior argues about whether or not sentences could have been used to express something that is true or false, or "is statable" in Prior's jargon, instead of about whether or not they are true. Again, Williams misunderstands Prior. To understand why I believe Williams is mistaken, a brief explanation of the differences between sentences, timeless propositions and tensed propositions is in order.

I take the distinction between sentences, on the one hand, and propositions, on the other, as it is typically understood: a sentence is a string of symbols of a language expressing a proposition. Therefore, a proposition is what a sentence expresses. (Granted, this is circular. But it is not meant to be a definition.) For our purposes, we need not be concerned with whether or not propositions exist. Quine, for instance, does not believe in the existence of propositions. Taking sentences to express truths or falsehoods need not be tied here to the notions of extralinguistic entities like propositions, facts, contexts, meanings, or what have you. In fact, Prior seems to favor tieing his

notion of a proposition to the notion of a world state (Prior 1967, 189). I use the proposition terminology for simplicity of understanding and because Prior uses it. This terminology can be exchanged for any of the other corresponding ontological terminologies without affecting the conclusions I draw here.

Prior draws a distinction between "temporal propositions" and "nontemporal propositions", the distinction between propositions that have different truth-values at different times, and propositions that have the same truth-value at all times.[15,16] Most of the literature dealing with propositions would seem to presuppose that all propositions are "nontemporal". (This is certainly true of possible worlds analyses, where propositions are identified either with sets of possible worlds or with functions from possible worlds to truth values.) From this perspective Prior's distinction would appear misguided.

Prior takes propositions to function in two ways. First, propositions are taken to be the meanings of sentences. Second, propositions also function as truth bearers. To say of a sentence that it is true (false) is simply to say that the proposition that it expresses is true (false). The conviction that propositions play both of these roles when conjoined with a widely-shared linguistic intuition is readily seen to entail that some propositions have truth values that

---

15 There are other things which mayh make propositions change their truth values. For instance, location of utterance of sentence expressing a particular proposition may make a difference.

16 Prior refers to "tensed" and "tenseless" propositions in 1968, 16n. and TLFC, and also in "timeless", "temporal" and "nontemporal" propositions in *Past, Present and Future*. I have chosen the modifiers "temporal" and "nontemporal" over "tensed" and "tenseless", since the latter carry with them unwanted reference to verb tenses instead of their direct connection with time. Moreover, I have not chosen the modifier "timeless" since I could not find a suitable antonym.

change from one time to another. The intuition is that (1) there are some sentences that have a truth value that varies from context to context, and (2) some of these sentences are unambiguous. Consider, for example, the sentence "Today is Friday", which is true of but one day of the week. It would appear to be unambiguous. It would be silly to suppose that it means one thing on Fridays, something that makes it true, and another thing on Tuesdays, something that makes it false. It would seem to follow that the proposition that it expresses or means (*Today's being Friday*) has a truth value that varies from time to time.

Sentences satisfying both conditions (1) and (2) will always be what Quine refers to as occasion sentences. Indeed Prior's distinction between temporal and nontemporal propositions is perhaps best understood as an analogue to the Quinean distinction between occasion and eternal sentences. Temporal propositions are those that are expressed by occasion sentences. Nontemporal propositions are those that are expressed by eternal sentences.

Returning to a rebuttal for Prior, Prior refers, as Williams recognizes, to something distinct from nontemporal propositions. However, instead of Prior arguing about sentences, as Williams maintains, he is arguing about the status of propositions. For he believes that some propositions are temporal, neither nontemporal propositions alone nor sentences are adequate in logic (Øhrstrøm & Hasle 1993, 31). That expresses the essence of his tensed view of time: temporal propositions, unlike nontemporal propositions, change truth-values and/or gain a truth-value with time. Only temporal propositions can capture Prior's metaphysical concerns.

Moreover, Prior is not talking about sentences, for while it is true that he believes that no one would have uttered that sentence, or any other sentence referring to a proposition about Andrew's marital state at the time and meant the same thing that we do now by those words (as all of us would agree), he believes so because the proposition addressed by the sentences could not have been true. And he believes the latter since the state of affairs would not allow predication: since Andrew did not exist, there was no Andrew of which a marital status could be considered a property. Therefore, Andrew could not be assigned to any predicates in logic. In *Past, Present, and Future* Prior makes this very point:

> [To say that something is statable] has the disadvantage of suggesting that the difficulty here is simply with our mechanisms of reference; I want to say rather that there are no *facts* about x to be stated except when x exists (Prior 1967, 147).

The problem to which Prior alludes is that no predicate can be applied to an individual at a moment when it does not exist.

In short, Prior's position is not much different from Williams's, although Williams would have us believe so. True, Prior is not speaking of nontemporal propositions. Prior means "temporal propositions" when he says "propositions". And his use of "proposition" can be taken as "states of affairs", just what Williams prefers.

2.5 THE PROBLEM EXTENDED

In this section I would like to entertain a deeper complication, that is, the interdefinability of the tense connectives "P" and "H", with "H" taken to mean "It has always been the case that". "H" is often

taken to mean the same as "It is not the case that it was the case that it is not the case that", which gives us the following definition:

H_{df} $HA =_{df} -P-A.$

From H_{df}, the normal notion of equivalence, and the introduction of negation we get the wff HP↔:

HP↔ $-HA \leftrightarrow P-A.$

Prior accepts only half of HP↔. In particular, he accepts:

PH→ $P-A \rightarrow -HA.$

If it was the case that it is not the case that A, then it has not always been the case that A. But, he denies:

HP↔ $-HA \leftrightarrow P-A.$

It is possible that there were states of affairs where "It is not the case that it was the case that A", that is, -PA. Clearly, if it is not the case that it was the case that A, then it is not the case that it has always been the case that A, i.e., -HA. Yet it may be that it never was the case that "A" was false, i.e. it is not the case that it was the case that not A, -P-A. Therefore, HP→ fails, making it impossible that "-HA" is equivalent to "P-A".

I will now adopt Prior's terminology in illustrating this case. There were possible states of affairs in which there were no facts about an individual. Thus there could not have been a proposition "p" about the individual. Supposing that there *never* was a moment at which there was a fact expressible by the proposition "p", "Pp" cannot be true.

Moreover, there was no proposition which asserted -p, either. So, "P-p" could not be true either. However, "-Hp" would be true, for it was not the case that "p" has always been true. Therefore, HP→ fails; thus, HP ↔ fails.

To sum up, Prior has concerns about propositions and therefore wffs containing nonreferring subjects. In particular, if the wffs are nonreferring, then they are not true. However, normal tense logic does not recognize these problems. Prior argues that these problems manifest themselves in various wffs, such as C2, HP→, and HP↔, normally taken to be logically true. I will now move on to the consideration of the alternative he suggests for tense logic. I will take the minimal system K_t to be the "standard" tense logic.

3 PRIOR'S QUANTIFIED TENSE LOGIC QQKt

In this section I will give a semantic reconstruction of Prior's quantified tense logic QQK_t. First, however, I will consider a simpler system, Prior's minimal propositional system, QK_t, which alters the minimal system K_t in two basic ways. First, it introduces new connectives "Y" for "was always statable" and "T" for "will always be statable". And second, it introduces new definitions for "H" and the analogous future tense connective "G" for "It will always be the case that". While laying out QK_t, I will address Prior's justification for these changes. Only after I have finished laying out and discussing QK_t will I move to QQK_t. QQK_t makes the same types of changes to K_t, with considerations appropriate to quantification.

3.1 PRIOR'S PROPOSITIONAL TENSE LOGIC QKt

I will give a semantic reconstruction of QK_t, Prior's propositional tense logic. First, I will present Prior's axiomatization; second, I will discuss the changes QK_t makes to K_t; third, I will give the semantic reconstruction; finally, I will show how QK_t allows for Prior to deny the conditional C2, "-PA → P-A".

3.1.1 SYNTAX FOR QK_t

The atomic formulas of QK_t include a denumerably infinite set of *sentence letters* "p", "q", and "r" with or without subscripts, the *connectives* "→", "-", "P", "F", "H", "G", "Y", and "T", and the *parenthesis* "(" and ")".

The notion of well-formedness is defined inductively:

FRS Sentence letters are wffs.

FR- If A is a wff, then -A is a wff.

FR→ If A and B are wffs, then A → B is a wff.

FRP If A is a wff, then PA is a wff.

FRF If A is a wff, then FA is a wff.

FRH If A is a wff, then HA is a wff.

FRG If A is a wff, then GA is a wff.

FRY If A is a wff, then YA is a wff.

FRT If A is a wff, then TA is a wff.

FRC Nothing else is a wff.

Intuitively, the connectives "→", "-", "P", "F", "H", and "G" are standard. However, to remind the reader, the connectives "T" and "Y" can be understood intuitively as the following:

IY "Y" for "has always been statable".

IT "T" for "will always be statable".

Prior got "Y" and "T" from "Yesterday" and "Tomorrow".

3.1.2 QK_t's AXIOMS AND RULES

The following axioms are grouped and labeled according to the systems from which they originate: PC1-PC3 originate from propositional calculus; K_t1-K_t4 come from the minimal tense logic, K_t; and QK_tY1-QK_tPT are specific to Prior's QK_t. One may note that the axiom and rule sets of K_t are subsets of those of QK_t. Prior takes K_t to be insufficient to account for the true nature of time and existence. This is evident from the fact that QK_t derives from his criticisms of K_t.

The axioms of QK_t are:

PC1: $((A \rightarrow (B \rightarrow C)) \rightarrow ((A \rightarrow B) \rightarrow (A \rightarrow C))$

PC2: $((-A \rightarrow -B) \rightarrow (B \rightarrow A))$

PC3: $(A \rightarrow (B \rightarrow A))$

K_t2: $-P-(A \rightarrow B) \rightarrow (-P-A \rightarrow -P-B)$

K_t1: $-F-(A \rightarrow B) \rightarrow (-F-A \rightarrow -F-B)$

K_t3: $P-F-A \rightarrow A$

K_t4: $F-P-A \rightarrow A$

QK_tY1: $YA \rightarrow Ys$, where s is any sentence letter in A.

QK_tY2: $(Ys_1 \ \& \ \ldots \ \& \ Ys_n) \rightarrow YA$, where $s_1, \ldots, s_n$ are all the sentence letters in A.

QK_tT1: $TA \rightarrow Ts$, where s is any sentence letter in A.

QK_tT2: $(Ts_1 \ \& \ \ldots \ \& \ Ts_n) \rightarrow TA$, where $s_1, \ldots, s_n$ are all the sentence letters in A.

QK_tPY1: $(Ys_1 \ \& \ \ldots \ \& \ Ys_n) \rightarrow ((-P-(A \rightarrow B) \rightarrow (PA \rightarrow PB)$ where $s_1, \ldots, s_n$ are all the sentence letters in B, but not in A.

QK_tFT1: $(Ts_1 \ \& \ \ldots \ \& \ Ts_n) \rightarrow ((-F-(A \rightarrow B) \rightarrow (FA \rightarrow FB))$ where $s_1, \ldots, s_n$ are all the sentence letters in B, but not in A.

QK_tPT: $PTA \rightarrow TA$.

QK_tFY: $FYA \rightarrow YA$.

The rules of QK_t are modus ponens, substitution, and the following two rules from K_t:

RG: } A => } -F-A

RH: } A => } -P-A

The thesis of the system are those wffs that can be generated from the axioms by finitely many applications of the rules of inference.

3.1.3 DIFFERENCES BETWEEN K_t AND QK_t

The axioms PC1-K_t4 are standard, thus requiring no additional comment. QK_tY1-QK_tPT, being unique to QK_t, require brief explanation. These axioms make room for the denial of C2. I will address each set of concerns in turn.

3.1.3.1 ADDITIONAL AXIOMS

QK_tY1-QK_tT2 reflect Prior's intuitive accounts of the connectives "Y" and "T". A wff is statable if and only if all of its component wffs are statable. Clearly, each component wff is statable if and only if all of *its* component wffs are statable, and so on until we reach the condition that the sentence letters must be statable. Thus, if all of

the component sentence letters are statable, then each one is statable. Since the same reasoning applies to "has always been statable" and "will always be statable", he introduces axioms that state if a wff always was or always will be statable, then any particular component sentence letter always was or always will be statable. Thus, he gets QK_tY1 and QK_tT1. QK_tY2 and QK_tT2 reflect the same intuitions: if all of the component sentence letters of a wff always were or always will be statable, then the wff as a whole always was or always will be statable. Formalized, we get the four axioms QK_tY1-QK_tT2.

QK_tPT-QK_tFY follow from the intuitive accounts of "Y" and "T", also. If in the past a wff was always going to be statable, then, surely, it *is now* always going to be statable forward from this point in time; and if in the future a wff was always statable in its past, then, surely, it *was* always statable backward from this point in time.

3.1.3.2 DENIAL OF THE IMPLICATION C2

Prior's misgivings about C2 motivated the addition of the axioms discussed in section 3.1.2.1 He denies C2 by refusing to interdefine the temporal connectives "H" and "P" by themselves, i.e., he denies H_{df}. Instead, he gives the following definition:

$$HPY_{df}\ HA =_{df} YA \ \&\ -P-A.$$

Thus, it is possible that "-P-A" be true while "HA" is false.

An interesting point becomes apparent: "HA" is rarely true. "HA" is only true on those occasions where A is either necessarily true, or is true and about something that has always existed. The former has a large enough domain. However, the latter could include only

propositions about the universe, God, numbers, sets, or whatever one takes to be the things which have always existed.

3.1.4 SEMANTICAL RECONSTRUCTION OF QK_t

The atomic formulas and wffs of the reconstruction of QK_t are the same as those in the axiomatic presentation of QK_t. I will begin by defining what it means to be an interpretation for QK_t; then I will define the notions of truth and falsehood under an interpretation. A brief discussion of the results of this reconstruction will close out the reconstruction of QK_t. Only then will we move to Prior's tensed predicate logic, QQK_t.

3.1.4.1 THE NOTION OF AN INTERPRETATION FOR QK_t

An interpretation I for QK_t is taken to be an ordered quadruple <t,T,R,V>, where the members can be thought of intuitively as:

i. T is the set of instants of time.

ii. t is the present instant.

iii. R is the earlier-than relation on T, with no conditions.

iv. V is a partial function which specifies the truth-values of sentence letters relative to instants of time.

The first thing to note is that an interpretation I represents the universe at a particular moment in time, indicated by t. Since V assigns truth-values to the sentence letters relative to the members of T, the truth-value of a sentence letter may differ relative to different members of T. Therefore, a sentence letter which gets assigned the truth-value "truth" relative to a particular moment t' of T, may get the

truth-value falsehood at a different time t'' of T. For example, take "p" to represent "Andrew is married". If "p" is uttered at time t' before he was married, then "p" is false. However, at time t'', after he was married, "p" would be true.

There was a third scenario from our example above: "Andrew is married" uttered before he was born. In such a case "Andrew is married" is neither true nor false, according to Prior. In more formal clothes Prior calls such propositions "unstatable". V is a *partial* function. Thus some sentence letters may not get assigned truth-values relative to a particular member of T. Specifically, this covers times when there is no fact to which the proposition referred to by the sentence letter corresponds.

With these intuitions in mind, we now move to the formal conditions on the members of I = <t,T,R,V>. The members of the quadruple I are defined:

i. T is any nonempty set.

ii. $t \in T$.

iii. $R \supseteq T^2$.

iv. V is a partial function such that if $t' \in T$ and $s \in SL$ and if V is defined for <t',s>, then $V(t',s) \in \{f,t\}$.

As related above, the relation R has no conditions, thus making this a minimal system.

3.1.4.2 TRUTH CONDITIONS ON QK_t

For the truth conditions of QK_t I will use the following shorthand. "A is statable under I" means "A is either true or false

under I". Truth and falsehood under an interpretation I = <t,T,R,V> are defined simultaneously:

TS If A is a sentence letter, then A is true under I iff V(t,A) = t; and A is false under I iff V(t,A) = f.

T→ If A is (B → C), then A is true under I iff both B and C are either true or false under I and either B is false or C is true under I; and A is false under I iff both B is true under I and C is false under I.

T- If A is -B, then A is true under I iff B is false under I; and A is false under I iff B is true under I.

TP If A is PB, then A is true under I iff B is either true or false under I, and for some t' such that R(t',t), B is true under <t',T,R,V>; and A is false under I iff B is either true or false under I, and for all t' such that R(t',t), B is not true under <t',T,R,V>.

TF If A is FB, then A is true under I iff B is either true or false under I, and for some t' such that R(t,t'), B is true under <t',T,R,V>; and A is false under I iff B is either true or false under I, and for some t' such that R(t,t'), B is true under <t',T,R,V>.

TY If A is YB, then A is true under I iff B is either true or false under I, and for all t' such that R(t',t), B is either true or false under <t',T,R,V>; and A is false under I iff B is either true or false under I, and for some t' such that R(t',t), B is neither true nor false under <t',T,R,V>.

TT If A is TB, then A is true under I iff B is either true or false under I, and for all t' such that R(t,t'), B is either true or false under <t',T,R,V>; and A is false under I iff B is either true or false under I, and for some t' such that R(t,t'), B is neither true nor false under <t',T,R,V>.

TH If A is HB, then A is true under I iff both YB and -P-B are true under I; and A is false under I iff either YB or -P-B are false under I.

TG If A is GB, then A is true under I iff both TB and -F-B are true under I; and A is false under I iff either TB or -F-B are false under I.

These truth conditions can be conveniently represented in the following tables, the first for truth and the second for falsehood. The

second table is unnecessary in both standard propositional logic and K_t. For a wff is either true or not true, with "not true" corresponding to "false". However, with Prior, we need to set up conditions under which a sentence can be neither true nor false. This can only be accomplished if falsehood is not identified as the absence of truth.

The first column lists all of the possible forms for the wff A. The second column lists the conditions under which A, which is of the form to the left, is true (false) with respect to the interpretation I.

If A is	Then A is true under I (= <t,T,R,V>) iff
a sentence letter	V(t,A) = t.
B → C	both B and C are statable under I, and either B is false or C is true under I.
-B	B is false under I.
PB	B is statable under I, and for some t' such that R(t',t), B is true under <t',T,R,V>.
FB	B is statable under I, and for some t' such that R(t,t'), B is true under <t',T,R,V>.
YB	B is statable under I, and for all t' such that R(t',t), B is statable under <t',T,R,V>.
TB	B is statable under I, and for all t' such that R(t,t'), B is statable under <t',T,R,V>.
HB	both YB and -P-B are true under I.
GB	both TB and -F-B are true under I.

If A is	Then A is false under I iff
a sentence letter	V(t,A) = f.
B → C	both B is true and C are false under I.
-B	B is true under I.
PB	B is statable under I, and for some t' such that R(t',t), B is not true under <t',T,R,V>.
FB	B is statable under I, and for some t' such that R(t,t'), B is not true under <t',T,R,V>.
YB	B is statable under I, and for some t' such that R(t',t), B is not statable under <t',T,R,V>.
TB	B is statable under I, and for some t' such that R(t,t'), B is not statable under <t',T,R,V>.
HB	either YB is false or -P-B is false under I.
GB	either TB is false or -F-B is false under I.

3.1.5 A COUNTEREXAMPLE

Now we are ready to construct a counterexample for the motivating wff C2 in QK_t. The complete list of motivating wffs is comprised of:

HP→ -HA → P-A.

HP↔ -HA ↔ P-A.

C2 -PA → P-A.

As far as HP→ and HP↔ go, they do not hold on account of the definition of "H":

H_{df} $HA =_{df} YA \ \& \ -P-A$.

By this definition it is easy to see that it is logically possible that "HA" be false and "-P-A" be true. Thus, it is logically possible that -HA and -P-A; therefore, "-HA" can be true while "P-A" can be false, allowing for HP→ and HP↔ to be falsified. Since this is clear from the above definition, I will provide counterexamples for neither wff.

For a counterexample to C2 consider the interpretation I = <2, {1,2}, {<1,2>}, {<<2,"p">,t>}>. Since this is the first interpretation given, I will explain the notation for the reader. The first three members of the quadruple should be clear enough; the first is an element of the second member; the second member is a nonempty set; and the third member represents an ordering relation on the second member. The fourth member represents the assignment of a truth-value to a sentence letter relative to a particular member of T, the second member of the interpretation. Thus, "<<2,"p">,t>" means that "p" gets the value truth relative to time 2.

To avoid this notation in the future, I can be represented conveniently in tabular form. Consider Table 3.1. The members of the set represented by "T", in the account of I, can be listed across the top, in the order specified by the ordering relation represented by "R", in the account of I. The first member of the quadruple will be underlined. The sentence letters can run down the left side. The values, represented by "t" and "f" for truth and falsehood, respectively, assigned by V to the wff at the left, relative to the member of T at the top, are at the intersections of the columns and rows. In this table I have included the values for the wffs, separated

by a double line, as determined by the assignment rules, appropriate to provide the desired counterexample.

Members → of T	1	2
p	-	t
-p	-	f
Pp	-	f
-Pp	-	t
P-p	-	f
-Pp → P-p	-	f

Table 3.1

Note that I have highlighted the wff in question, C2, and its value. We have the desired counterexample. Unless otherwise specified, I will hereafter represent interpretations for counterexamples in this way. Therefore, QQK_t allows for the denials which Prior desired.

3.2 PRIOR'S PREDICATE TENSE LOGIC QQK_t

Now I will give a semantic reconstruction of QQK_t.[17] It is based on Prior 1967 and 1968. As with QK_t, I will begin by giving Prior's axiomatization of QQK_t.

3.2.1 WELL-FORMED FORMULAS FOR QQK_t

The atomic formulas of QQK_t include those of QK_t together with variables, n-place predicates for each $n \geq 1$, the identity sign "=", and

[17] Prior calls this system the predicate calculus based on QK_t, giving no formal name. I have used QQK_t to indicate the *quantified* QK_t.

"Σ". Where v is any variable, "(v)" is the universal quantifier and "(Σv)" is the existential quantifier. The n-place predicates of QQK_t are the letters "M", "N", and "O" with superscript n and with or without subscripts. The variables are the letters "x", "y", and "z" with or without subscripts. The set of sentence letters will be called "SL".

The definitions of well-formedness for QQK_t can be obtained by adding four new clauses to the definition of well-formedness for QK_t:

FRR If Q is an n-place predicate and v_1, ..., and v_n are variables, then $Q(v_1...v_n)$ is a wff.

FRI If v_1 and v_2 are variables, then $v_1 = v_2$ is a wff.

FRU If A is a wff and v is a variable, then (v)A is a wff.

FRΣ If A is a wff and v is a variable, then (Σv)A is a wff.

FRC Nothing else is a wff.

That completes the definition of well-formedness.

3.2.2 QQK_t'S AXIOMS AND RULES

To make the axioms and rules shorter and more perspicuous, I will occasionally use "&" for conjunction, "v" for alternation, the connective "S" for "is always statable", the notation "()A" for the universal closure of the wff A, and the notation "Q(**v**)" to abbreviate the predication "$Q(v_1...v_n)$". Let them be defined by:

$\&_{df}$ $(A \ \& \ B) =_{df} -(A \rightarrow -B)$.

v_{df} $(A \ v \ B) =_{df} (-A \rightarrow B)$.

S_{df} $SA =_{df} YA \ \& \ TA$.

UC_{df} $()A =_{df} (v_n)...(v_1)A$, where v_1, ..., v_n are all of the variables free in A.

$Q\mathbf{v}_{df}$ $Q(\mathbf{v}) =_{df} Q(v_1 \ldots v_n)$, where Q is any n-place predicate.

In Prior's QQK_t, *the axioms for quantifiers are standard.* So, in addition to the standard propositional axioms PC1-PC3, we get the following set of standard predicate axioms, U1-Σ2:

U1: $(v_1)A(v_1) \rightarrow A(v_2)$, where v_2 is free for v_1 in $A(v_1)$.

Σ1: $-(\Sigma v_1)-A(v_1) \rightarrow A(v_2)$, where v_2 is free for v_1 in $A(v_1)$.

U2: $(v)(A \rightarrow B) \rightarrow (A \rightarrow (v)B)$, where A contains no free occurrence of v.

Σ2: $-(\Sigma v)-(A \rightarrow B) \rightarrow (A \rightarrow -(\Sigma v)-B)$, where A contains no free occurrence of v.

The major changes come in the axioms which include the connectives "Y" and "T":

QQY1: } $YA \rightarrow Y(v_1)\ldots(v_n)Q(v_1 \ldots v_n)$, where Q is any predicate which occurs in A.

QQT1: } $TA \rightarrow T(v_1)\ldots(v_n)Q(v_1 \ldots v_n)$, where Q is any predicate which occurs in A.

QQY2: } $YA \rightarrow Yv = v$, where v occurs free in A.

QQT2: } $TA \rightarrow Tv = v$, where v occurs free in A.

QQY3: } $(Ys_1 \;\&\; \ldots \;\&\; Ys_i \;\&\; Y()Q_1(\mathbf{v}) \;\&\; \ldots \;\&\; Y()Q_j(\mathbf{v}) \;\&\; \ldots \;\&\; Yv_1 = v_1 \;\&\; \ldots \;\&\; Yv_k = v_k) \rightarrow YA$, where $s_1, \ldots, s_i$ are all the variables occurring free for sentence letters in A, where $Q_1, \ldots, Q_j$ are all the predicates in A, and where $v_1, \ldots, v_k$ are all the variables occurring free for individuals in A.

QQT3: } $(Ts_1 \;\&\; \ldots \;\&\; Ts_i \;\&\; T()Q_1(\mathbf{v}) \;\&\; \ldots \;\&\; T()Q_j(\mathbf{v}) \;\&\; Tv_1 = v_1 \;\&\; \ldots \;\&\; Tv_k = v_k) \rightarrow TA$, where $s_1, \ldots, s_i$ are all the variables occurring free for sentence letters in A, where $Q_1, \ldots, Q_j$ are all the predicates in A, and where $v_1, \ldots, v_k$ are all the variables occurring free for individuals in A.

As for the rules of inference, the following are standard for quantifiers:

RU1: $\vdash (A \rightarrow B) \Rightarrow \vdash ((v)A \rightarrow B)$, for v not free in A.

RΣ1: $\vdash (A \rightarrow B) \Rightarrow \vdash (-(\Sigma v)-A \rightarrow B)$, for v not free in B.

RU2: $\vdash (A \rightarrow B) \Rightarrow \vdash (A \rightarrow (v)B)$.

RΣ2: $\vdash (A \rightarrow B) \Rightarrow \vdash (A \rightarrow -(\Sigma v)-B)$.

However, the rules for the connectives "Y" and "T" add complexity.

RPY1: $\vdash (A \rightarrow B) \Rightarrow \vdash (Ps_1 \,\&\, \ldots \,\&\, Ps_i \,\&\, Y()Q_1(\mathbf{v}) \,\&\, \ldots \,\&\, Y()Q_j(\mathbf{v}) \,\&\, Yv_1 = v_1 \,\&\, \ldots \,\&\, Yv_k = v_k) \rightarrow (Y((A \vee FA) \vee PA)) \rightarrow Y\overline{B})$, where all the variables in A (bound or free) are within the scope of ((A v FA) v PA)) or a Y, and where $s_1, \ldots, s_i$ are all the variables occurring free for sentence letters in B but not in A, where $Q_1, \ldots, Q_j$ are all the predicates in B but not in A, and where $v_1, \ldots, v_k$ are all the variables occurring free for individuals in B but not in A.

RFT1: $\vdash (A \rightarrow B) \Rightarrow \vdash (Fs_1 \,\&\, \ldots \,\&\, Fs_i \,\&\, T()Q_1(\mathbf{v}) \,\&\, \ldots \,\&\, T()Q_j(\mathbf{v}) \,\&\, Tv_1 = v_1 \,\&\, \ldots \,\&\, Tv_k = v_k) \rightarrow (T((A \vee FA) \vee PA)) \rightarrow T\overline{B})$, where all variables (bound or free) are within the scope of ((A v FA) v PA)) or a T, and where $s_1, \ldots, s_i$ are all the variables occurring free for sentence letters in B but not in A, where $Q_1, \ldots, Q_j$ are all the predicates in B but not in A, and where $v_1, \ldots, v_k$ are all the variables occurring free for individuals in B but not in A.

RQMP: $\vdash A, \vdash (A \rightarrow B) \Rightarrow \vdash (Sv_1 = v_1 \,\&\, \ldots \,\&\, Sv_i = v_i) \rightarrow B$, where $v_1, \ldots, v_i$ are all the individual variables which occur free in A but not in B.

3.2.3 DIFFERENCES BETWEEN QUANTIFIED K_t AND QQK_t

There are only a few significant differences between the changes QK_t makes to K_t and the changes which QQK_t makes to the quantified K_t. The most significant result of the changes made in QQK_t is that the

tense logic equivalents of the "Barcan Formula", "$P(\Sigma v)A \rightarrow (\Sigma v)PA$" and "$F(\Sigma v)A \rightarrow (\Sigma v)FA$", do not obtain (Prior 1968, 158).[18]

The second most significant change is the rule for *modus ponens*. It adds the necessary statability of all of the variables free in A but not in B, of $\vdash A \rightarrow B$. This change is meant to allow the possibility of an empty universe and thus the possibility of our expressing that the universe was or will be empty. This concern derives from the fact that a wff can be a theorem even when it is never true, as long as it is never false. "x=x" and "$(x=x \rightarrow (\Sigma x)x=x)$" are always true, when statable, and thus never false. However, "$(\Sigma x)x=x$" means that the universe must always be nonempty. Prior does not want to preclude such a possibility (Prior 1968, 159).

The remaining changes to QQK_t reflect analogous changes made in the propositional case. For example, the differences between the axioms in the quantified K_t and QQK_t are the same as those between K_t and QK_t. More results obtain, but only as consequences of adding quantifiers, not as a result in significant changes to the quantification.

3.2.3 SEMANTIC RECONSTRUCTION OF QQK_t

3.2.3.1 THE NOTION OF AN INTERPRETATION IN QQK_t

An interpretation I for QQK_t is taken to be an ordered sextuple <t,T,R,P,V,D>, where: t, T, and R remain as in QK_t; but V changes, and P and D are new. P, D, and V can be taken intuitively as follows:

i. P is a set of individuals, past, present, and future.

---

[18] Prior actually only discusses the Barcan Formula with respect to Q, the modal fragment of QQK_t, and the system on which he bases QQK_t, and the system on which he bases QQK_t.

ii. D picks out all individuals that exist at time t'. D(t'), then, represents the set of all individuals existing at time t'.

iii. V assigns, relative to every member of T, in addition to "t" and "f" to sentence letters, sets of n-tuples of members of the set D(t') to n-place predicates.

V changes from a partial function merely assigning truth-values to sentence letters, to also assigning sets of n-tuples of individuals to predicates.

More formally, the members of an interpretation I for QQK_t fulfill the following conditions:

i. T is any nonempty set.

ii. $t \in T$.

iii. $R \supseteq T^2$.

iv. V is a partial function such that if $t' \in T$, then:

a. if $s \in SL$ and V is defined for $\langle t',s \rangle$, then $V(t',s) \in \{f,t\}$; and

b. if Q is an n-place predicate, then $V(t',Q) \in D(t')^n$.

v. D is a function from T into P such that for each $t' \in T$, $D(t') \supseteq P$.

As is apparent, the formal considerations of t, T, and R remain the same as in the propositional case. The formal aspects of V, however, change.

V is still a partial function. However, V is expanded in QQK_t to make assignments to predicates, in addition to the members of SL. While V may or may not be defined for particular sentence letters, V is defined for all predicates. Thus, all predicates are defined, even though there may be no sequences of individuals which fit them relative to t.

The addition of P and D are needed to add individuals, predicates, and, thus, quantification to the propositional logic.

3.2.3.2 EVALUATION CONDITIONS IN QQK_t

An evaluation relative to an interpretation <t,T,R,P,V,D> is a function that assigns to each variable a member of P. When reference to the interpretation is not explicit, it will be clear by context. Two evaluations e and e' are *v-variants* if and only if they differ at most in the element of P they assign to v, i.e., if and only if for each v', e(v') = e'(v') unless v' = v.

QQK_t must allow wffs either to have the standard truth-values of truth and falsehood, or to be truth-valueless. Truth is classically defined as satisfaction by all evaluations (under an interpretation), and falsehood is defined as being not-truth. Therefore, a wff must have either the value truth or the value falsehood. QQK_t, however, needs a third option, making the notion of satisfaction inadequate. I introduce, as the counterpart of satisfaction, the notion of *verification* and its contrary notion of *falsification*, while leaving it possible to have wffs which are neither verified nor falsified.[19]

Prior draws the distinction between those wffs which are either true or false and those which are neither, by referring to their "statability". I will use an analogous notion of statability with respect to evaluations to simplify truth conditions. "A is statable under I" means that "A is either verified or falsified by e under I", and "A is unstatable under I" means that "A is neither verified nor

---

[19] "Verification" and "falsification" carry with them unintended epistemological connotations. I am not appealing to our ability to verify or falsify any particular information, beliefs, etc.

falsified by e under I". Prior notes that "[QK_t] clearly collapses to K_t if we add the postulates Ã T[A] [and] Ã Y[A]..." (Prior 1968, 151) It is safe to assume that if we added corresponding assumptions to QQK_t that it would collapse to a quantified K_t.

The notions of verification and falsification are defined by simultaneous inductions. Let e be an arbitrary evaluation relative to <t,T,R,P,V,D>.

If A is	Then e verifies A under I iff
a sentence letter	$V(t,A) = t$.
n-place predicate $Q(v_1 \ldots v_n)$	$\langle e(v_1),\ldots,e(v_n)\rangle \in V(t,Q)$.
$v_1 = v_2$	$e(v_1), e(v_2) \in D(t)$ and $e(v_1) = e(v_2)$.
$(B \rightarrow C)$	B and C are both statable under I, and either e falsifies B under I or e verifies C under I.
-B	e falsifies B under I.
PB	B is statable under I, and for some t' such that R(t',t), e verifies B under <t',T,R,P,V,D>.
FB	B is statable under I, and for some t' such that R(t,t'), e verifies B under <t',T,R,P,V,D>.
YB	B is statable under I, and for each t' such that R(t',t), B is statable under <t',T,R,P,V,D>.
TB	B is statable under I, and for each t' such that R(t,t'), B is statable under <t',T,R,P,V,D>.
HB	e verifies both YB and -P-B under I.
GB	e verifies both TB and -F-B under I.
(v)B	for every $e(v') \in D(t)$, e' verifies B under I.
$(\Sigma v)B$	for at least $e(v') \in D(t)$, e' verifies B under I.

The falsification conditions for QQK_t are as follows:

If A is	Then e falsifies A under I iff
a sentence letter	$V(t,A) = f$.
n-place predicate $Q(v_1 \ldots v_n)$	$e(v_1) \ldots e(v_n) \in D(t)$ and e does not verify $Q(v_1 \ldots v_n)$ under I.
$v_1 = v_2$	$e(v_1), e(v_2) \in D(t)$ and $e(v_1) \neq e(v_2)$.
$(B \rightarrow C)$	e verifies B and falsifies C under I.
-B	e verifies B under I.
PB	B is statable under I, and there is no t' such that R(t',t), and e verifies B under <t',T,R,P,V,D>.
FB	B is statable under I, and there is no t' such that R(t,t'), and e verifies B under <t',T,R,P,V,D>.
YB	B is statable under I, and for some t' such that R(t',t), B is not statable under <t',T,R,P,V,D>.
TB	B is statable under I, and for some t' such that R(t,t'), B is not statable under <t',T,R,P,V,D>.
HB	e falsifies either YB or -P-B under I.
GB	e falsifies either TB or -F-B under I.
(v)B	A is not verified under I.
(Σv)B	A is not verified under I.

A is true under I if and only if it is verified by all evaluations under the interpretation I. A is logically true if and only if it is falsified under no interpretations. A is false relative to I if and

only if it is falsified by at least evaluation under I. A is logically false if it is falsified under all interpretations. As is easy to see, formally this reconstruction of Prior's QQK_t does not make sentences about nonexisting individuals false, as Prior's discussions suggest. Instead, they become truth-valueless.

3.2.4 A COUNTEREXAMPLE

Prior criticizes K_t for allowing C2 to go through. More generally, Prior is concerned with quantified K_t's handling of individuals which do not exist at t, and traces the problem back to the tense logic equivalents of the Barcan Formula (Prior 1968, 158-159):

BFP: $P(\Sigma v)A \rightarrow (\Sigma v)PA$.

BFF: $F(\Sigma v)A \rightarrow (\Sigma v)FA$.

BFP and BFF both hold in the quantified version of K_t since quantifiers range over past, present, and future individuals. However, consider Table 3.2, which represents an interpretation which provides a counterexample for BFP under QQK_t.

Table 3.2 differs from the previous counterexample table in several ways. First of all, the members of the domain P are listed in the row marked "P". Secondly, the members of D(u), where u is a variable for the members of T, are included under the respective times in the row labeled "D". If a member of D(u) occurs under one member of T but not under another, then that member of D(u) exists at the time indicated by the member of T under which it occurs, but not at the time indicated by the member of T under which it does not occur. The third change is the addition of a line indicating the ordered n-tuples which

are assigned to each predicate relative to a particular member of T. For the rows P, D, and for predicates, "{}" means that the set is empty. Fourth, I have included a line indicating the individual assigned to a particular variable x by an evaluation e, labeled e_x. The fifth change is that "v" and "f" are used instead of "t" and "f" in accordance with changes in the evaluation conditions for QQK_t. A dash, "-", means that the wff has no truth-value relative to the time indicated at the top of the column, i.e., is unstatable.

Let the evaluation e assign Socrates to the variable "x", i.e., e("x") = Socrates. In Table 3.2 I will abbreviate "Socrates" by "S".

Members of T →	1	2
P	{S}	
D	{S}	{}
M	{<S>}	{}
Mx	v	-
PMx	f	-
(Σx)Mx	v	f
P(Σx)Mx	-	v
(Σx)P(Mx)	-	f
P(Σx)Mx → (Σx)P(Mx)	-	f

Table 3.2

The relevant formula and its value relative to 2 are highlighted for BFP. The antecedent is verified, while the consequent is falsified. Therefore, we have the desired counterexample.

4 CONCLUSION

To sum up, I have given a semantic reconstruction of QQK_t which I believe adequately represents Prior's QQK_t. The reconstruction allows for the desired counterexample to the past tense equivalent of the Barcan Formula, and analogous things can be said about the future tense equivalent. The Barcan Formulae are at the root of Prior's concerns about quantifying over nonpresent existents. Thus, Prior has created a system which allows for quantification only over (presently) existing individuals. Therefore, QQK_t is consistent with a dynamic view of time. In Chapter 4 I will more fully relate QQK_t to Chapter 2 and discuss difficulties to which that relationship gives rise. We will find that Prior's QQK_t leads to a radical time solipsism.

CHAPTER 4

QQK$_t$, SPECIAL RELATIVITY, AND DILEMMAS

1 INTRODUCTION

In Chapter 2, section 3.1, I addressed the apparent asymmetry between the past and the future and its manifestation in the doctrine of the Degrees of Reality (DR). To refresh the reader's memory, DR postulates three increasing degrees of reality which correspond to the future, the past, and the present, respectively. Proponents of a dynamic theory of time (DT) often rely on DR to make sense of the apparent asymmetry between the past and the future. Consider Figure 4.1.

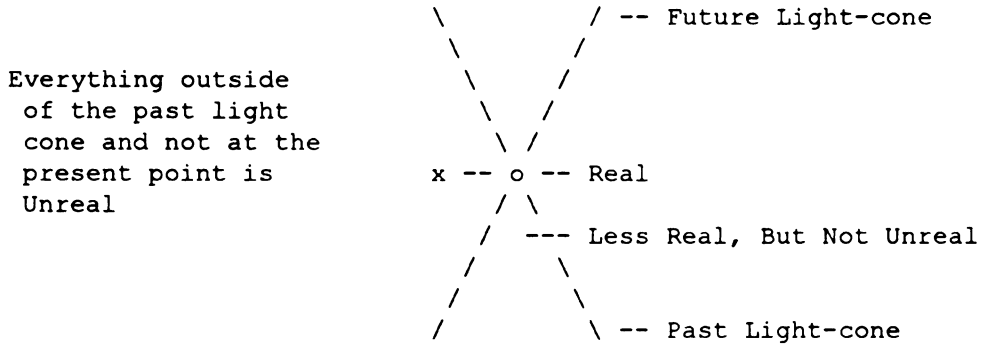


Figure 4.1

There are three "reality zones": (a) the "real" is at x's spatial-temporal Now; (b) the "less real" is within x's past light-cone; and (c) the "unreal" is everything not included in either (a) or (b).

Therefore, the past and the future have different degrees of reality. Since the past had a causal effect on the present, even though it no longer exists, the past "has" a certain reality. The future, however, is neither here yet nor has any causal effect on the present. Therefore, it is unreal. Moreover, each reality zone is relative to a particular x.

However, the tense logician must work with strict ontology. The P-tenser, in particular, must work with the ontology represented in Figure 4.2:

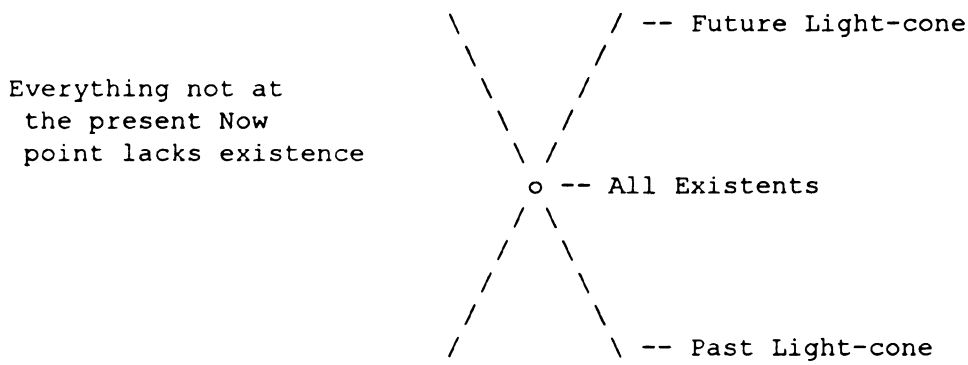


Figure 4.2

All existent individuals are at the present Now point, according to the P-tenser.

This chapter is concerned with DT and its relationship to QQK_t. In section 2.1 I will show that QQK_t treats past and future tense operators symmetrically. In section 2.2 I will address whether the P-tenser should be superstitious about the past and thus deny such symmetry.

In sections 3.1 and 3.2 I will consider two concerns brought about by assigning individuals which do not exist *at* the present the same ontological status as present individuals. In section 3.1 I will show

how QQK_t addresses the problem of distinguishing between individuals which existed but no longer exist from individuals which never have, do not now, and never will exist. I will call that problem the Socrates/Pegasus problem. In section 3.2 I will show how QQK_t complicates the expression of relationships between noncontemporary individuals. In section 3.3 I will summarize the complexities to which the considerations in section 3.1 and 3.2 lead.

There is another, very deep problem with which the P-tenser is confronted. Consider Figure 4.2 again. All existence is at the present Now point, or rather, the *here-now point*. As I argued in Chapter 2, if the P-tenser desires to remain true to Special Relativity (SR), then the P-tenser must accept that existence is confined to a particular spatio-temporal location. Therefore, solipsism results: there is only one object in the present, that is, only one individual for the domain D(t) of <t,T,R,P,V,D>, for QQK_t. In section 4.1 I will address this *present point solipsism* in which QQK_t lands if it is to remain true to SR. Moreover, QQK_t combined with SR lands the P-tenser in an even more radical solipsism, one which allows for only one object in the domain, P. I address this *world line solipsism* in section 4.2.

2 REALITY, EXISTENCE, AND SUPERSTITION

Neither past nor future individuals exist for proponents of DT. DR uses a middle ground of causal connectedness. But that middle ground does not include existence. In his treatment of logic, then, the P-tenser as a proponent of DT seems to have no logic-related use for DR's middle ground. In sections 2.1 and 2.2 I will briefly entertain the

results for QQK_t, and explain why the P-tenser maintains the symmetry of nonexistence between the past and the future.

2.1 QQK_t, THE PAST, AND THE FUTURE

Clearly, QQK_t maintains symmetry between the past and the future. One only need look at the evaluation rules in Chapter 3 to notice that the only difference between the treatment of wffs containing "P" and "F" involves the relation R: the evaluation rules for "P" use "R(t',t)" and the evaluation rules for "F" use "R(t,t')". Otherwise, the corresponding rules are identical.

To further emphasize this symmetry, consider, again, the tense logic equivalents of the Barcan Formula.

BFP $P(\Sigma v)A \rightarrow (\Sigma v)PA$

BFF $F(\Sigma v)A \rightarrow (\Sigma v)FA$

In neither case does the consequent follow from the antecedent. Substitute "Mx" for "A" and "x" for "v". Although x may have M'ed in the past or will M in the future, there may be nothing which presently exists which M's. BFP and BFF treat both past and future individuals the same: it is possible that neither exist presently, yet we can reference them within the scope of a tense connective.

So what does this indicate about QQK_t? One of the most interesting results is that it does not suggest that the future is any less determined than the past. In other words, it allows that future tensed wffs may be true Now (verifiable relative to the interpretation I), even though the future has not yet obtained. This seems to run contrary to Prior's own stance against determinism (Prior 1967, 113-

136). But such a discussion is beyond the scope of this inquiry, for QQK_t is a minimal system. Therefore, Prior neither sets conditions on R, nor privileges past or future individuals.

2.2 SUPERSTITION AND THE PAST

Despite all this, Prior does consider the possibility of privileging members of D(t'), where t' ∈ T and R(t',t) of an interpretation <t,T,R,P,V,D>, i.e., past individuals. The P-tenser may (1) count only present existents as legitimate values of variables, or (2) allow present *and past* existents as legitimate values of variables. Given DR, (2) may seem legitimate. This is an attractive option for the P-tenser as it agrees with his intuitions and it allows the P-tenser to do in logic as we do in language -- take statements about the past to be statable. However, Prior rejects it.

Consider BFP again. BFP failed because an instance of "P(**Σ**v)A", say "P(**Σ**x)Mx", is verifiable while a corresponding instance of "(**Σ**v)PA", i.e., "(**Σ**x)PMx", is falsifiable. The counterexample obtains because it corresponds with the intuition that although there may *have existed* something which M'ed, there may be nothing which *now exists* and M's. Therefore, the counterexample to BFP shows that QQK_t corresponds to such intuitions. However, if (2) where accepted, then BFP would go through. (2) takes things which have existed to have the same ontological status as present existents. Therefore, if present existents exist, then past ones do also; and if we take things which exist as legitimate values of bound variables and we take present existents as legitimate values, then we must take past existents, also.

Thus, BFP must go through: if something, say x, existed which M'ed, then something "now" exists to M, namely, x.

How would such a change affect QQK_t? For starters, evaluation rules would have to be changed. That could be accomplished fairly simply by taking out the statability clause for past tensed connective "P". Secondly, "T" would become superfluous, since if something is now statable, then it always will be statable. Thirdly, "G" would become equivalent to "-F-", since "T" would be superfluous. Thus, accepting (2) would change QQK_t significantly, narrowing the gap between it and quantified K_t.

But that is not something which the P-tenser would want to do, not merely because of the changes it would make to QQK_t, but because it would allow for BFP to go through. Prior calls a position which takes the future as existing *superstitious*: it gives the future a ghostly existence. Prior points out that to be superstitious about the past is still to be superstitious (Massey 1969, 23; Prior 1967, 160). He notes that although we may want to call the past more real than the future, we cannot assign it existence. Thus, he does not privilege the past.

3 PRESENT AND PAST EXISTENTS, AND NONEXISTENTS

In the preceding sections I considered treating past and future individuals asymmetrically. In short, I concluded that Prior finds it necessary to treat past individuals as nonexistents just as he treats future individuals. This is consistent with SR, as I presented it in Chapter 2. However, new concerns arise. In this section I will consider two possible problems for Prior. The first is how to distinguish individuals which existed in the past, but do not now, from

those which do not exist now and neither have existed nor will exist. I will call this the "Socrates/Pegasus" problem, or "SP" for short. The second problem I will present is how to express relations between present existents, and past but not present existents. I will call this the "Socrates Height" problem, or "SH" for short.

3.1 SOCRATES AND PEGASUS

Consider the following problem. How can QQK_t distinguish objects which existed in the past from things that never existed, and never will, if both are nonexistent now? For example, there seems to be a difference between Socrates and Pegasus. According to DR and to our intuitions (although not to the de-tenser's view), Socrates is in a sense real whereas Pegasus is accordingly unreal. For even though Socrates may not exist now, he did exist in the past and had a causal effect on present existents (for example, Socrates influenced Plato's writings, which survive until today). Pegasus has not existed, will not exist (presumably), and has no causal effect on present existents. However, in some sense we cannot say that Socrates' ontological status is any different from Pegasus': neither exist now. The point is that we are speaking in two areas: the area of DR covers our intuitions and epistemic concerns, but the area of actual existence covers our metaphysical concerns. It seems that we cannot treat Socrates differently than Pegasus.

Prior allows a solution to this problem. Prior denies the propriety of quantifying over past existents, *but only when the quantifier is not within the scope of a tense connective.* Consider "$(\Sigma v)PA$" and "$P(\Sigma v)A$", again. Now consider the following example,

representing the relevant parts of an interpretation which represents the state of our universe. In particular, let t_s be some time when Socrates was alive and t_n be some time when he isn't alive, such that $R(t_s,t_n)$. Intuitively, take "M" to mean "Socratizes" and "N" to mean "Pegasizes". Let Table 4.1 represent an interpretation, just as we did in Chapter 3. Let e("x") = Socrates.

Members → of T	t_s	t_n
P	Socrates	
D	Socrates	{}
M	Socrates	{}
N	{}	{}
Mx	v	-
Nx	f	-
(Σx)Mx	v	f
(Σx)Nx	f	f
PMx	f	-
PNx	f	-
P(Σx)Mx	f	v
P(Σx)Nx	f	f
(Σx)PMx	f	f
(Σx)PNx	f	f

Table 4.1

I have captured the relevant information in this table.

Now we can see how Prior draws a distinction between objects which existed in the past, but no longer exist, and objects which have never existed. In QQK_t Prior quantifies over past existents, like Socrates, so long as the quantifiers are within the scope of the past tense operator. Therefore, in this example "$P(\Sigma x)Mx$" is verified under I, while "$(\Sigma x)PMx$" remains unverified under I. However, QQK_t does not allow for quantification in any form over *never existents*, like Pegasus. Therefore, in this example neither "$P(\Sigma x)Nx$" nor "$(\Sigma x)PNx$" are verified under I. Thus, past, but not present, existents are distinguishable from never existents.

3.2 SOCRATES AND WILT "THE STILT"

The Barcan Formula and the Socrates/Pegasus problem are primarily motivated by Prior's intuitions that individuals like Socrates, did exist, but do not now exist. Another question arises, how does one construct predicates in QQK_t in order to express relationships between noncontemporary existents? For example, how do we express a comparison of height relationship between Socrates and Wilt Chamberlain? Socrates was rather short; and Wilt "The Stilt" is rather tall; so we might be tempted to say "Wilt is taller than Socrates". How could that be translated?

Take T to represent the predicate "is taller than", and e("x") to pick out Wilt, and e("y") to pick out Socrates. Consider the following translation:

FT1 Txy.

A variable (of an evaluation under an interpretation) meant to refer to Socrates is not assigned to any member of D(t'), where t' $\in$ T, if Socrates is not a member of D(t'), that is, does not exist at t'. And a variable meant to refer to Wilt is not assigned to any member of D(t') if Wilt is not a member of D(t'). If they both existed at the same time, there would not be any problem. For example, "Wilt is taller than Irvin 'Magic' Johnson" would be correctly translated by FT1, where e("x") picks out Wilt and e("y") picks out Magic. However, since Wilt and Socrates do not exist at the same time, they would never both be members of the same D(t'). Remember that for any n-place predicate Q, $V(Q,t') \in D(t')^n$, that is, the function V only assigns subsets of $D(t')^n$ to n-place predicates. Thus, they would never be assigned to the same predicate under the same interpretation. Therefore, TF1 can be neither verified nor falsified (when translating "Wilt is taller than Socrates").

Prior offers two solutions to SH, or more generally, the problem of expressing relationships between noncontemporary existents. According to Prior the statement expressed by "Wilt is taller than Socrates" can be dealt with in two ways: (1) by translating it as a relationship between absolute measurements; or (2) by translating it as a series of relationships between contemporaries (Prior 1967, 169-171). I will address each in turn.

3.2.1 Absolute Measurements Solution

(1) would be accomplished in the following way. First consider an intermediate translation:

IT2 There is an x and a y such that both x and y are numbers and there is a z such that z Wiltizes and z stands x inches tall, and there was an x_1 such that x_1 Socratizes and x_1 stood y inches tall, and x is greater than y.

Notice that IT2 expresses the relationship via absolute values for sizes. So, z and x_1 are only compared indirectly. If we take "N" to mean "is a number", "W" to mean "Wiltizes", "I" to mean "stands ... inches tall", "S" to mean "Socratizes", and "G" to mean "is greater than", then the following is a possible translation into QQK_t:

FT2 $(\Sigma x)(\Sigma y)(Nx \ \& \ Ny \ \& \ (\Sigma z)(Wz \ \& \ Izx) \ \& \ P(\Sigma x_1)(Sy \ \& \ Ix_1y) \ \& \ Gxy)$.

Clearly, FT2 is much more awkward than FT1, and it relies on absoluteness of size measurements, which we know from SR to be dubious anyway.

3.2.2 Relationships Between Contemporaries

(2) fares even worse. Begin with the intuitive translation IT3:

IT3 There is an x and a y such that x Wiltizes and x is taller than y, and there was a z such that y is taller than z, and there was an x_1 such that z was taller than x_1 and ... and there was a y_n such that x_n is taller than y_n, and there was a z_n such that z_n Socratizes and y_n is taller than z_n.

From IT3 the formal translation is:

FT3 $(\Sigma x)(\Sigma y)(Wx \ \& \ Txy \ \& \ P(\Sigma z)(Tyz \ \& \ P(\Sigma x_1)(Tzx_1 \ \& \ ... \ \& \ P(\Sigma y_n)(Tx_ny_n \ \& \ P(\Sigma z_n)(Sz_n \ \& \ Ty_nz_n)))))$

FT3 expresses relationships between contemporaries: v_k must always be a contemporary of v_{k+1}, and v_{k+1} a contemporary of v_{k+2}, while v_k need not be a contemporary of v_{k+2}, where $v_k, v_{k+1}, v_{k+2} \in \{x,...,z_n\}$. In fact,

choosing the longest living individuals, with the least lifetime overlap, and requiring that v_k cannot be a contemporary of v_{k+2} keeps the translation the shortest possible FT3-type.

However, there are two serious problems with FT3: a definitional problem and an analytical/empirical problem. Concerning the definitional problem, the number of individuals between noncontemporary individuals will vary with the individuals being compared and the relationship between them being expressed. Therefore, Prior has to include the variable "n" as a subscript in FT3. Thus "n" occurs free in FT3, the *definiens*. This breaks the formal rule of definitions that a variable free in the *definiens* must occur free in the *definiendum*.

The second problem with this solution is that it becomes analytically true that ever since Socrates existed there has been someone taller than him. For, by definition the empirical fact that Wilt is taller than Socrates means that there has been an unbroken series of individuals who are taller than Socrates. Although it probably is in fact the case that there has been such an unbroken series, it should not be an analytic fact that if two noncontemporaries share a particular relationship there is an unbroken series of contemporaries between them that share the same relationship.

In the sense that it does not make dubious assumptions about the absolute differences between measurements, dubious in the sense that relativity theory calls the whole notion of absolute sizes into question, FT3 is better than FT2. However, based purely on length and the number of individuals necessary, FT3 is much more awkward than FT2. Moreover, there are even more serious problems. In particular, FT3 breaks the rules for formal definitions and it makes what should be an

empirical fact into an analytic truth. No matter which we choose, however, both options are much more awkward than "Txy".

3.3 SUMMARY

To sum up, Prior can deny the tense logic counterparts of the Barcan Formula, BFP and BFF. Moreover, he can get around both SP and SH: past, but not present existents are distinguishable from never existents, and relationships between noncontemporary individuals can be expressed in QQK_t. The cost in terms of simplicity is high, however. To deny BFP and BFF, QQK_t required the statability clause, addition of the connectives "Y" and "T", redefinition of the connectives "H" and "G", and an allowance for truth-valueless wffs. To distinguish the various temporally placed individuals, Prior had to deny simple straight forward translations like FT1 in favor of awkward hunks of notation like FT2 and FT3. Although the problems are resolvable within QQK_t, Prior remains true to his intuitions at the expense of simplicity.

4 SOLIPSISM AND SR

QQK_t is, in Prior's own words, awkward. From complex evaluation rules to complex ways of handling relationships between contemporary, noncontemporary, and never existents, Prior made changes to standard logic which many logicians would and have found unacceptable. Massey, for instance, extensively criticized Prior's awkward systems in his "*Tense Logic? Why Bother!*". Quine has criticized Prior's reliance on "common sense dynamic time" as the basis to his project.[20] However, the

---

[20] See, for example, "Mr. Strawson on Logical Theory".

most severe insult of all, it seems to me, is the fact QQK_t has never caught on, except at the fringes of philosophical logic.

The primary reason for objecting to Prior's efforts has been the generally accepted belief that SR implies that past, present, and future individuals possess the same ontological status. In Chapter 2 I showed that Massey, Quine, and Putnam appealed to the neo-Eleatic view of time. However, I argued that such a view of time is incorrect. If I am right, many logicians such as Massey and Quine cannot object to Prior's project on such grounds. There must be other reasons for objecting to Prior. Massey and Putnam *do provide* some other reasons.

First of all, since the Now does not spread instantaneously and orthogonally to spatial dimensions, only things at a particular spatial point exist. Therefore, only one object can be a member of D(t) of an interpretation, <t,T,R,P,V,D>. I will call this "present point solipsism", or "PPS" for short. Secondly, if the first condition holds, then for each t' $\in$ T, D(t') must contain only one member, which just happens to be the same member as is the member of D(t). I call this "world line solipsism", or "WLS" for short. Thus, Massey makes an interesting point: although Prior tries to take time seriously, he does not appear to take the physics of time seriously (Massey 1969, 24). In section 4.1 I will explain PPS. In section 4.2 I will show that the more radical WLS develops.

4.1 PRESENT POINT SOLIPSISM

Putnam has argued that SR puts us in the dilemma that either nothing exists but itself for something or that everything exists for everything else, regardless of spatial-temporal locations (Putnam 1967,

240). The second horn of the dilemma supports the de-tenser and C-tenser views. In this traditional view of SR time is merely one dimension in the four dimensional manifold of spacetime. Time is spatialized. In Chapter 2, I argued that this is the wrong way to conceptualize time. Instead, we should take time as dynamic, with a privileged Now-point which brings things into existence, which suggests the first horn of the dilemma.

The P-tenser view is supported by the first horn of the dilemma. But, that horn leaves Prior and the P-tensers in a difficult position. The Now-point can only be defined locally, that is, it spreads neither instantaneously nor orthogonally with respect to spatial dimensions. This results in the present existing as a point-instant. The Now-point, which defines the present, can only be made sense of at the time-space of that Now's present. The only things which exist for any possible observer are those which exist at the Now-point. And only one thing exists at any particular Now-point. Therefore, the set D(t) has one member.[21] Therefore, PPS obtains.

Clearly, this result leads to a severely limited tense logic. Thus, Massey concludes, "Prior did not pay sufficient attention to these matters and that, insofar as any theory of time affected his early philosophical thinking about tense logics, it was the commonsensical Newtonean theory..." (Massey 1969, 25). It seems that Massey is correct in *this* assessment since commonsensical Newtonean theory suggests that

---

[21] One may be inclined to include individuals in spatial contact with the one member of D(t). However, this would need much working out and seems arbitrary, since even then they are not coincident with each other.

time spreads instantaneously and orthogonally with respect to the spatial dimensions, thus allowing D(t) to have multiple members.

4.2 WORLD LINE SOLIPSISM AND THE BARCAN FORMULAS

If P-tensers carry their position to its logical conclusion, they must hold that a solipsism even more radical than PPS obtains. If nothing but what is at the present Now-point on, say, x's world line ever exists, then only objects that are coincident with x's world line ever existed in the past or ever will exist in the future (see Figure 4.3).[22] In other words, at any time in the past or future, only objects coincident with x existed or will exist. Clearly, this is a problem for the P-tenser, for only x can be the value of a bound variable, *even if the quantifier is within the scope of a tense operator*! Nothing exists but x, and nothing has ever existed in x's past but x itself, and nothing ever will exist in x's future, but x itself (Massey 1969, 24-25).

[22] From here on I will only discuss the past tense case. But symmetrical things can be said about the future tense case.

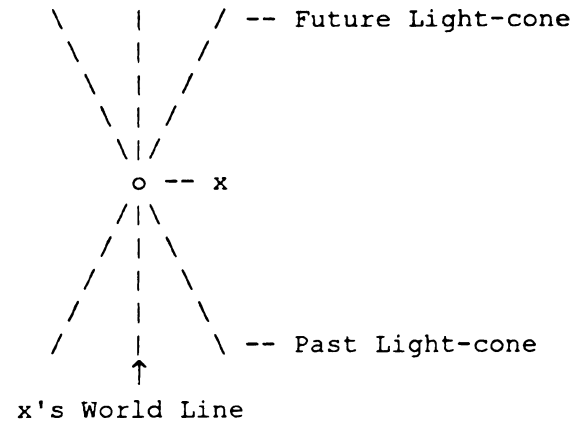


Figure 4.3: Existence is defined by x's world line. For x, the only thing to have ever existed, or ever to exist is x itself. WLS results.

If, indeed, WLS obtains, then x is the only individual which can possibly be a member of the set D(t'), for all t' $\in$ T. Moreover, P is made up of only the one member x. But more importantly, since there will never be a case where D(t') contains anything different from x, there cannot be a counterexample to the tense logic equivalent of the Barcan Formula which remains true to the P-tenser's metaphysics, except in the case that D(t) of <t,T,R,P,V,D> is empty.

Consider BFP again:

BFP $\quad P(\Sigma v)A \rightarrow (\Sigma v)PA$

Suppose this line of thought is incorrect: D(t) is not empty and BFP is falsified. There would have to be a member of D(t) which is not the individual which verifies, for example, "$P(\Sigma x)Mx$", otherwise "$(\Sigma x)PMx$" would be verified, also. The individual which verifies the antecedent but leaves the consequent falsified would have to be another individual which is not a member of D(t) but is a member of P and D(t'), where t' $\in$ T and R(t',t). But this contradicts WLS. So, BFP can only be falsified when D(t) is empty, i.e., nothing exists.

This example poses two problems for Prior. First, this seems to run counter to his own counterexamples. He clearly uses individuals which are supposed to exist in a world inhabited by many individuals, and has been inhabited by many other individuals. But that is not fatal to his position, for a counterexample can be constructed: the universe simply needs to be empty. However, this is a trivial counterexample and contrary to the universe we envision. Do we want to consider such an empty universe and then develop a tense logic to handle it? The universe would be lonely, and the logic impotent.

5 CONCLUSION

To conclude this chapter I will summarize the P-tenser's problems. First of all, Massey was correct when he said that Prior's system is complicated. In Chapter 3 I discussed various formal complications. Prior adds the two complicating connectives "Y" and "T", for "has always been statable" and "will always be statable", respectively. Moreover, they would only come to minimal use as they only make sense when either the subjects of their statements have (will) always existed (exist) or they are expressing necessary truths about things which have (will) always existed (exist). The only things which fulfil the first criterion, presumably, would be God, if one exists, the universe, numbers, sets and other abstract entities, etc.

Moreover, he redefines the connectives "H" and "G", for "It has always been the case that" and "It will always be the case that", respectively. But the set of propositions that would verify instances of them is a subset of the propositions about things that have existed from the beginning of time or will exist for eternity. So, although

this may be an infinite set, it does not include things that we have often taken to have always been or to always be true. For example, if both p = "My Grandfather is American" and q = "Andrew is married", then neither "Hp" nor "Gq" are true, although my Grandfather was American and Andrew will probably be married for the rest of his life.

Further complications are the uncommon demands made on our logic systems. For instance, many wffs are neither verified nor falsified under an interpretation. For example, an instance of the Law of Excluded Middle itself will be unstatable when its wffs have no subject denotation, that is, neither "A" nor "-A" get either verified or falsified in those cases.

That takes care of the problems addressed in Chapter 3. However, they continue in Chapter 4. Prior's demands add complications to translations: SP is resolvable by adding to the overall complexity of translations; SH suggests not only the complexity of translation into QQK_t, but also introduces possible definitional problems, as well. For example, relationships between noncontemporary individuals require very complex translations.

Even if one accepts all this awkwardness, a more damaging criticism arises against Prior. As Massey points out, Prior neglects the physics of time. Prior claims to want to create a logic that is metaphysically pleasing. But he neglects the fact that SR's present is a point-instant. Thus if the present defines existence, then the only existent is what exists at that point-instant. Therefore, PPS obtains: there is only one member of any set of present existents. Moreover, that individual is the only possible member of any set D(t'), for all t' $\in$ T. Thus, the problems that he wanted to solve from the beginning

become trivial. Given all of these complications, Prior's QQK_t seems untenable.

It seems that the DT position may itself need to be jettisoned if we are to have logic at all. In Chapter 5 I will present the C-tenser and explain his attempts to solve this problem. I will conclude that the C-tenser does not remain true to our metaphysical concerns. Moreover, even if we disregard our metaphysical concerns, the C-tenser is subject to debilitating problems.

CHAPTER 5

THE C-TENSER

1 INTRODUCTION

In Chapter 3 and 4 I discussed the P-tense system QQK_t and evaluated it with respect to a dynamic conception of time relative to special relativity (SR). We found that QQK_t remains true to SR at great cost. First of all, it becomes painfully obvious that QQK_t is exceedingly awkward: the various evaluation conditions become exceeding complex, relative to K_t; expressing relations between noncontemporaries is very complicated; QQK_t has definitional problems; and QQK_t takes some facts as analytic, although they should be empirical. Moreover, QQK_t combined with the here-now of SR leads to present-point solipsism (PPS) and world-line solipsism (WLS).

In this chapter I will entertain a C-tense version of tense logic. Cocchiarella makes the neo-Eleatic assumption of tenseless existence. Nonetheless, he develops a tense logic, which I will call APK_t. In sections 2.2-2.2.3 I will present his logic in accord with the notation I used for my reconstruction of QQK_t. Cocchiarella adds two new quantifiers and limits the standard quantifiers from K_t. In sections 3-3.2.2 I will discuss Cocchiarella's use of quantifiers and its relation to his notion of comprehensive objecthood (CO). In sections 4-4.2 I will compare APK_t with QQK_t. APK_t yields similar results to QQK_t with

regard to the tense logic equivalents of the Barcan Formula. However, it yields results similar to K_t with respect to the other formulas which provoked Prior's quest for a metaphysically pleasing tense logic.

In sections 5-5.2.2 I will evaluate APK_t with respect to SR. At that point, I do not make any assumptions about the truth or falsehood of the neo-Eleatic view of time. I will conclude that APK_t lands the C-tenser in problems similar to PPS and WLS, as faced by the P-tenser. All of this, however, disregards my argument in Chapter 2 for a dynamic view of time. If I am correct, then the C-tenser does not produce a metaphysically pleasing system, and is thus inadequate on these grounds also.

2 THE C-TENSE SYSTEM APK_t

In this section I will present Cocchiarella's tense logic for actual and possible existents, APK_t, with the notation used in earlier chapters. Cocchiarella has presented APK_t both axiomatically and semantically. I will use his semantics, presenting them differently from, although I believe equivalent to, his presentation. Framing his system in the notation from earlier chapters of this essay makes easier a comparison of APK_t and QQK_t. Nonetheless, I will reference, and briefly explain, his presentation in the discussion of comprehensive objecthood (CO) in section 3.2-3.2.2 I will give a reconstruction of APK_t in sections 2.2-2.2.3. First, however, I will lay out some preliminaries in section 2.1.

2.1 PRELIMINARIES

I will use the same metalinguistic notation as in previous chapters. I will refer to Cocchiarella's tense logic system as "APK_t". The "K_t" in "APK_t" was chosen because it, like QQK_t, is a modification of K_t. I chose the letters "A" and "P" because Cocchiarella refers to it as a logic of ***actual*** and ***possible*** objects. In his dissertation he gives examples of what he means by actual and possible objects. I will return to this later when giving his justification for the introduction of new quantifiers. At this time suffice it to say that he takes actual objects to be those which exist presently, and he calls the members of the set of all actual objects "*actualia*". He takes possible objects to be those objects which have existed in the past, exist presently, or will exist in the future. Therefore, the set of *actualia* is a subset of the set of possible objects, objects he calls "*possibilia*".

Such vocabulary is slightly misleading. He, like the de-tenser, believes that all objects exist tenselessly in accord with the neo-Eleatic conception of time. Therefore, to say that an object existed in the past is to speak from within the temporal framework imposed on a tenseless universe, all the while recognizing the tenseless existence of *possibilia*.

Cocchiarella also suggests two other classes of objects which could be taken as *possibilia*: (1) things which never have, do not, and never will exist, although they *could* have existed, and (2) things which *could* be members of the domain of a possible world (other models) in the Kripkean sense, even though not in fact a member of the domain of the actual world ("this" model). I will return to these options in sections 3.1-3.1.2.

2.2 SEMANTICS FOR APK_t

Let us now proceed to the presentation. I will begin by giving formation rules; move on to the notion of an interpretation; and end with the presentation of evaluation rules relative to an interpretation.

2.2.1 SYNTAX

APK_t makes two changes in the list of atomic formulas from that of QQK_t: APK_t does not include the connectives "Y" and "T"; and Cocchiarella adds to the set of quantifiers a universal *possible* quantifier "[v]" and an existential *possible* quantifier "[Σv]", where v is an individual variable.

In addition to FRS-FRG and FRR-FRΣ of QQK_t, APK_t has the following formation rules:

F[] If A is wff and v is a variable, then [v]A is a wff.

F[Σ] If A is wff and v is a variable, then [Σv]A is a wff.

Intuitively, the new quantifiers can be taken to be the same as the standard quantifiers, with one exception. The new quantifiers range over all of the members of P whereas the standard quantifiers only range over the members of D(t), the sets in an interpretation under APK_t like that under QQK_t. Since P is the set of all *possibilia*, he calls the new quantifiers the *possible quantifiers*; and since D(t) is the set of all *actualia*, he calls the old quantifiers the *actual quantifiers*. I will make use of his terminology.

The reader familiar with Cocchiarella may notice that I have excluded names in this presentation. I have done so to make comparisons

between Cocchiarella and Prior simpler. Names can be added without significant effect on the conclusions I will draw.

2.2.2 THE NOTION OF AN INTERPRETATION

An interpretation I for APK_t is taken to be an ordered sextuple <t,T,R,P,V,D>, where t, T, R, P, and D remain the same as in QQK_t; but V changes. In APK_t V is a proper function: it assigns a truth-value to each sentence letter. Thus, formally the members of the interpretation I for APK_t meet the following conditions:

i. T is any nonempty set.

ii. $t \in T$.

iii. $R \supseteq T^2$.

iv. P is any nonempty set.

v. V is a function such that if $t' \in T$, then:

   a. if $s \in SL$, then $V(t',s) \in \{f,t\}$; and

   b. if $Q^n \in Pred$, then $V(t',Q^n) \in P^n$.

vi. D is a function from T into P such that for each $t' \in T$, $D(t') \supseteq P$.

As with APK_t, R carries no conditions, thus making APK_t a minimal system.

2.2.3 EVALUATION CONDITIONS ON APK_t

As with QQK_t, an evaluation relative to an interpretation assigns a member of P to each variable. When reference to the interpretation is not explicit the intended interpretation will be clear from context.

Two evaluations e and e' are v-variants if and only if they differ at most in the element e(v') of P they assign to v.

The C-tenser believes that *possibilia* exist in a broad sense, i.e., all individuals exist regardless of their temporal location. I will return to the details later. The upshot of this is that all wffs refer to existents. Thus, APK_t does not need to accommodate nonreferring wffs; therefore, all wffs are either verified or falsified. However, since no third (truth-valueless) option is needed I will dispense with the verification/falsification vocabulary and use Tarski's notion of *satisfaction*.

The standard notions of truth and falsehood are used: a wff is true relative to an interpretation I if and only if it is satisfied by all evaluations under I; a wff is logically true if and only if it is true under all interpretations; a wff is false relative to I if and only if it is not true relative to I; and a wff is logically false if and only if it is false under all interpretations.

Let e be an arbitrary evaluation relative to I (= <t,T,R,P,V,D>). The satisfaction conditions for APK_t are as follows:

If A is	Then e satisfies A under I iff
a sentence letter	$V(t,A) \in t$.
n-place predicate $Q(v_1 \ldots v_n)$	$\langle e(v_1),\ldots,e(v_n)\rangle \in V(t,Q)$.
$v_1 = v_2$	$e(v_1) = e(v_2)$.
$(B \rightarrow C)$	either e does not satisfy B under I or e satisfies C under I.
-B	e does not satisfy B under I.
PB	for some t' such that R(t',t), e satisfies B under <t',T,R,P,V,D>.
FB	for some t' such that R(t,t'), e satisfies B under <t',T,R,P,V,D>.
HB	for all t' such that R(t',t), e satisfies B under I.
GB	for all t' such that R(t,t'), e satisfies B under I.
(v)B	every v-variant of e, where e(v') $\in$ D(t), satisfies B under I.
($\exists$v)B	at least one v-variant of e, where e(v') $\in$ D(t), satisfies B under I.
[v]B	every v-variant of e satisfies B under I.
[$\exists$v]B	at least one v-variant of e satisfies B under I.

The reader may notice that the evaluation rules do not contain statability clauses. The reason is simple: Cocchiarella assumes the tenseless existence of all members of P. Thus, statability is not an issue, since all possible sentence letters get truth-values and all variables are assigned a tenselessly existing individual.

3 APK_t, QUANTIFIERS AND EXISTENTS

The most fundamental difference between the C-tenser and P-tenser is in the objects over which quantification is allowed. Therefore, the most significant issues for this inquiry lie in APK_t's quantification and the objects it treats as existents. In sections 3.1-3.1.2 I will explain APK_t use of quantifiers. In sections 3.2-3.2.2 I will lay out the C-tenser's basic assumptions about CO.

3.1 QUANTIFIERS

APK_t adds two quantifiers to its arsenal, the universal and the existential *possible* quantifiers "[v]" and "[Σv]", respectively. In section 3.1.1 I will give a brief explanation of how they differ from the universal and existential actual quantifiers "(v)" and "(Σv)". In section 3.1.2 I will give Cocchiarella's justification for adding them to tense logic.

3.1.1 ACTUAL v. POSSIBLE QUANTIFIERS

Actual quantifiers range *only over members of D(t)*, that is, they are analogous to the quantifiers of QQK_t. On the other hand, possible quantifiers range *over all of the members of P*. This distinction gives rise to the following implications:

EAP $(\Sigma v)A \Rightarrow [\Sigma v]A$

UPA $[v]A \Rightarrow (v)A$

However, the implications do not work in the opposite directions, i.e., the following implications do not hold:

EPA [Σv]A => (Σv)A

UAP (v)A => [v]A

Consider each in turn.

3.1.1.1 PROOFS FOR EAP AND UPA

Intuitively EAP holds. If a presently existing individual satisfies a formula, then some possible individual does, also, viz., the same individual. More formally, consider the following. Suppose that an instance of "(Σv)A" is satisfied and the corresponding instance of "[Σv]A" is unsatisfied. Since the instance of "(Σv)A" is satisfied there is some *actualia* which satisfies the wff "A", call it "x". By definition, all *actualia* are members of D(t) under <t,T,R,P,V,D>, for some t $\in$ T. Therefore, e("x") $\in$ D(t). Since D(t) [is a subset] of P, e("x") $\in$ P. We supposed above that "[Σx]A" is unsatisfied. The universal possible quantifier ranges of the set P. Thus, there are no members of P which satisfy "A". However, this is contrary to the conclusion just drawn. Therefore, EAP.

UPA is intuitively sensible, also. For, if every possible individual satisfies a formula, then every actual individual should also. More formally, suppose that an instance "[v]A" is satisfied and the corresponding instance of "(v)A" is unsatisfied. The instance of "[v]A" is satisfied when every v-variant (of e) satisfies the wff "A". Since D(t) $\supseteq$ P, under <t,T,R,P,V,D>, all members of D(t) must be members of P. Therefore, all v-variants where the substitutions are made by members of D(t), must satisfy "A", also. The instance of "(v)A" is unsatisfied when there is a member of D(t) whose v-variant does not satisfy "A". However, we have just seen that this is not possible if

the instance of "[v]A" is satisfied. Since the v-variant corresponding to each member of P satisfies "A" and at least one v-variant corresponding to a member of D(t) does not satisfy "A", there must be a member of D(t) which is not a member of P. However, that contradicts the defined relationship between D(t) and P. Therefore, UPA holds.

3.1.1.2 COUNTEREXAMPLES FOR EPA AND UAP

Next I will provide counterexamples for EPA and UAP. The counterexamples are based on the following facts about these wff forms. There may be *possibilia* which satisfy a wff of the form "[Σv]A" (relative to an interpretation), while no *actualia* satisfy such a wff; and all *actualia* may satisfy a wff of the form "(v)A", while not all *possibilia* satisfy a wff of the form "[v]A". Consider the interpretations represented in Table 5.1. I have made the appropriate changes in the layout of Tables 2 and 3 to account for satisfaction in APK_t. Let "Mx" be substituted for "A" in EPA and UPA and let e("x") = Socrates.

Members of T →	1
P	{Socrates}
M	{<Socrates>}
D	{}
Mx	s
[Σx]Mx	s
(Σx)Mx	u

Table 5.1

"[Σx]Mx" is satisfied relative to D(1) while "(Σx)Mx" is not because "[Σx]" of "[Σx]Mx" ranges over all *possibilia*, while "(Σx)" of "(Σx)Mx" only ranges over *actualia*. Since there is no member of D(1) which Ms, but there is a member of P which Ms, [Σx]Mx but not (Σx)Mx. Therefore, Table 5.1 provides a counterexample to EPA.

In order to arrive at a counterexample for UAP, alter the interpretation represented by Table 5.1 to include another member of P, which does not M and is a member of D(1). This situation leads to "Mx" prefixed by the universal actual quantifier being satisfied, while "Mx" prefixed by the universal possible quantifier is left unsatisfied. Let e("y") = Prior. Consider Table 5.2.

Members of T →	1
P	{Socrates, Prior}
M	{<Socrates>}
D	{Socrates}
Mx	s
My	u
(x)Mx	s
[x]Mx	u

Table 5.2

Under this interpretation, Socrates Ms, but Prior doesn't. Moreover, Socrates ∈ D(1) while Prior ∉ D(1). Thus, since all the members of D(1) M, but not all the members of P, (x)Mx but not [x]Mx. Thus, we have a counterexample UAP.

3.1.1.3 SUMMARY OF DIFFERENCES BETWEEN THE POSSIBLE AND ACTUAL QUANTIFIERS

In summary, possible quantifiers make significant changes to the range of quantification within APK_t. For, while actual quantifiers allow quantification over mere *actualia*, possible quantifiers allow quantification over *possibilia*. This expansion of quantification allows for differences in the truth conditions under the same interpretation expressible in the affirmation of the implications EAP and UPA, and the denial of the implications EPA and UAP.

3.1.2 JUSTIFYING POSSIBLE QUANTIFIERS

Clearly, possible quantifiers function differently from their actual counterparts. Moreover, they lead to various unsavory results in the eyes of the *P-tenser*. For example, objects which are *possibilia*, but not *actualia* can be quantified over; and nonpresent individuals are tantamount to *nonexisting* individuals for the P-tenser. So for the P-tenser, possible quantifiers quantify over nonexistents.

The C-tenser adheres to CO, giving no reason to be concerned with quantification over *possibilia*. Nonetheless, Cocchiarella is the first to add the new quantifiers. As Cocchiarella notes, Kripke treats the quantification over *possibilia* differently from quantification over *actualia* in modal logic (Cocchiarella 1966, 16; Kripke 1963, 7). Kripke's semantics in "Semantical Considerations on Modal Logic" take the assertion of, for example, the open formula "Mx" to be tantamount to the assertion that all *possibilia* satisfy "Mx". However, he does not allow the assertion of open formulas and suggests the replacement of all open formulas by their closure *with the standard, actual-like, quantifiers*.

So why has Cocchiarella done something which others, such as Kripke when considering analogous issues in modal logic, have not seen as necessary? Cocchiarella answers this by arguing that since we are distinguishing *possibilia* from *actualia* we should also distinguish quantification over them (Cocchiarella 1966, 16). Cocchiarella agrees with the P-tenser in that A =/> (v)A, where v is free in A, in a tensed system. For an open formula might be asserting something which does not apply to anything in the present. Given this, Cocchiarella points out that as a result of his alterations in quantification in APK_t if Kripke

is right that the assertion of a free formula A means that all *possibilia* are substitutable for the free variable(s) in A, then clearly A =/> (v)A. For "(v)" quantifies over mere *actualia*, not over all *possibilia*.

Cocchiarella takes the tension Kripke faces as an indication that the introduction of possible quantifiers is a useful refinement of tense logic. Possible quantifiers can help one distinguish between an open formula and a formula in which all variables are bound by actual quantifiers, in accord with the C-tenser's intuitive temporal concepts. Thus, the introduction of possible quantifiers incorporates the C-tense temporal intuitions into tense logic.

3.2 COMPREHENSIVE OBJECTHOOD

Cocchiarella's reasoning, as I have portrayed it in section 3.1.2, only works when either (1) quantification over nonexistents is allowed, or (2) *possibilia* share their (strict) ontological status with *actualia*. The de-tenser may be concerned that Cocchiarella opts for option (1) if he were to read the following passage from Cocchiarella:

> We point out that although the value of a variable need not be in the universe of a model, i.e., be an actual object of the model, the values of the variables bound by *q*, the universal actual quantifier, always are. Thus *to be* is not to be the value of a variable, nor is it to be the value of a bound variable; but rather, *to be* is to be the value of a variable bound by *q*, the universal actual quantifier (Cocchiarella 1966, 20).

At first blush, one might take Cocchiarella to be hostile to the notion of CO and to be at odds with Quine's oft quoted claim. Concerning Quine's claim, we will see that to draw such a conclusion would be to

equivocate on "to be". But first, let's take a look at Cocchiarella's stance on CO.

3.2.1 COCCHIARELLA AND COMPREHENSIVE OBJECTHOOD

The reader may recall from Chapter 3 that CO takes all individuals, both *possibilia* and *actualia*, to share the same ontological status. But as Massey points out, to attribute a rejection of this to Cocchiarella would be inaccurate (Massey 1969, 20). Cocchiarella clearly takes as the possible values of variables bound by his possible quantifiers, objects which *are not*, according to the quote above. And all quantification is to be only over objects which exist. It is just that for the P-tenser existence is defined by the present, while for the C-tenser existence includes "what has existed, exists now, or will exist" (Massey 1969, 21). The C-tenser clearly shares his ontological stance with the de-tenser. So how are we to understand the quote above, and especially the words "*to be* is to be the value of a variable bound by *q*, the universal actual quantifier"?

Cocchiarella argues that all *possibilia* must exist in some sense in order to "allay the nominalistic fears of some" (Cocchiarella 1966, 15). He wants his quantifiers to range only over existing objects. But he has two sorts of quantifiers, those which range only over *actualia* and those which range over *possibilia*. Therefore, *actualia* and *possibilia* both exist. A brief outline of Cocchiarella's semantics may prove useful to our understanding.

3.2.2 COCCHIARELLA'S HISTORIES AND MODELS

Instead of an ordered sextuple, Cocchiarella defines an interpretation to be the ordered quadruple <D,P,V,i>, where P roughly corresponds to P, D to D, V to V, and i to t, in my presentation above.[23] The quadruple represents the actual world for Cocchiarella. The set of possible worlds are defined in terms of a *history* H of a wff A. A history is an ordered pair <R,M*>, where M* is a nonempty set of models of A, and R is a serial ordering on M*. The models in M* can be considered instants of the history, which are temporally ordered by the relation R. The work of T and R together in my presentation is done by the ordering of the models of histories in Cocchiarella's work.[24]

3.2.3 HISTORIES, MODELS, INTERNAL AND EXTERNAL EXISTENCE

We may think of his distinction between possible and actual quantifiers as a distinction between *internal* and *external* quantifiers. The actual quantifiers "(v)" and "(Σv)" work internal to a model, taking only objects which are members of the set D(i) of that model as possible values of their variables. The possible quantifiers "[v]" and "[Σv]" range over the members of P. *De facto*, they range over all of the members each D(i)'s of all models in set H of models. Thought of in this way they have a range external to a particular model.

The words "to be" in the quote coincide with what a particular model takes as temporally existing. However, existence is not limited

---

[23] I will follow Massey's changes to Cocchiarella's notation as they do simplify Cocchiarella's sematical notation without taking away any intuitive content.

[24] This isn't completely true to Cocchiarella's presentation of his tense logic. I follow Massey who simplified its presentation in a few minor ways, without changing it substantively, thus making the important parts easier to understand.

to the members of D(i), for all members of all D(i)s exist without temporal qualification, i.e., they exist externally to a particular model. Thus, we have two types of existence, internal and external. Internal existence and external existence correspond with temporal and atemporal existence, respectively. External existence coincides the neo-Eleatic view of existence. Internal existence, on the other hand, coincides with what we experience as existing, viz., present existence.

Keeping with the vocabulary in this explanation, hereafter I will refer to these two types of existence as *internal* and *external* existence. Actual quantifiers range over all and only those things which the man on the street principle (MSO from Chapter 4) takes to be existing (with respect to a particular interpretation); possible quantifiers range over all *possibilia*, that is, all those things that the neo-Eleatic takes as existing. Clearly, the C-tenser adheres to CO.

3.2.4 "TO BE"

Returning to the Quinean way of expressing his view, we can see that "*to be* is to be the value of a variable bound by *q*, the universal actual quantifier" could be more accurately expressed "to be *atemporally* is to be the value of a bound variable, but to be *temporally* is to be the value of a variable bound by *q*, the universal actual quantifier". While Quine uses the phrase "to be" in the atemporal sense, Cocchiarella is using it in the sense of temporally qualified existence. Therefore, "to not be" in the temporally qualified sense still allows for the possibility of "to be" in the sense of what the C-tenser and de-tenser *really* mean.

3.3 SUMMARY

A brief summary of sections 3.1-3.2.4 is in order. The C-tenser treats the standard quantifiers "(v)" and "(Σv)" similarly to the way that the P-tenser does, in the sense that their range is the set of *actualia*. However, the C-tenser adds the possible quantifiers "[v]" and "[Σv]", which range over the set of *possibilia*. Therefore, the possible quantifiers in APK_t function similarly to the standard quantifiers in K_t. If the C-tenser wants to limit the range of quantification to existents, then the possible quantifiers functioning as they do depends on the C-tenser's adhering to CO. For, the C-tenser cannot allow quantifiers to range over objects which do not exist internally and also maintain that internal existence characterizes all existence. It is at this point where the C-tenser's conceptual views diverge the most from those of the P-tenser's. Next, I will move on to the formal manifestations of the conceptual differences.

4 COMPARING APK_t AND QQK_t

The difference in their ontological commitments lead the C-tenser and P-tenser down divergent formal paths. In the following sections I will present the formal differences between APK_t and QQK_t: I will show how CO manifests itself in the logical truth of various formulas under APK_t. In sections 4.1-4.1.2 I will show that given certain assumptions about the topology of time, the conditional C2 is logically valid under APK_t; and when a counterexample is logically possible, the basis for the counterexample is much different from those provided under QQK_t. In section 4.2.1 I will consider the logical relationship between the operators H and P: they can be interdefined in APK_t just as they can in

K_t. In section 4.2.2 I will consider various tense logical manifestations of the Barcan Formula. I will show that the tense logical formulas BFP and BFF are not logically true under APK_t. However, replacing the actual quantifiers with possible quantifiers produces tense logical formulas which are logically true.

4.1 THE CONDITIONAL C2

The reader may recall that Prior's discontent with the conditional C2, "-PA → P-A", motivates his quest for a true tense logic: it indicated to him a problem with ontological assumptions of standard propositional logic, modal logics, and both propositional and quantified K_t. Therefore, if QQK_t were to be adequate, it would have to disallow the logical truth of C2. The C-tenser does not share the P-tenser's ontological concerns. Therefore, it is not surprising to find that C2 is provable in APK_t, provided certain conditions hold.

Intuitively, it is easy to see why C2 may be taken as logically true in APK_t: it is not the case that it was the case that A just in case that at some time or other in the past it was not the case that A. More formally, consider the following *reductio*. Suppose that an instance of "-PA" is satisfied (by an evaluation) under an interpretation <t,T,R,P,V,D> and that the corresponding instance of "P-A" is unsatisfied under <t,T,R,P,V,D>. Since the instance of "-PA" is satisfied, the instance of "PA" is unsatisfied. An instance of "PA" is not satisfied when *it is not the case that* for some t' ∈ T such that R(t',t), "A" is satisfied under <t',T,R,P,V,D>. Moreover, if an instance of "P-A" is not satisfied under <t,T,R,P,V,D>, then it is not the case that "-A" is satisfied under <t',T,R,P,V,D>. "-A" is not

satisfied under <t',T,R,P,V,D> when *it is the case that* "A" is satisfied under <t',T,R,P,V,D>. But this is a contradiction. Therefore, C2 is logically true under APK_t.

C2 appears to be logically true under APK_t, unlike under QQK_t. This happens for three reasons. First, V is a proper function in APK_t. V assigns values to every sentence letter, regardless of the temporal status of the subjects of the sentence letters. Second, in APK_t every wff is either satisfied or unsatisfied, disanalogous to QQK_t where a wff may be verified, falsified, or neither verified nor falsified. Therefore, if the ontological assumptions underlying APK_t are correct, then the criticism that I suggested the P-tenser adopts against the proof of C2 in Chapter 3 cannot be leveled against a proof APK_t. It could not be leveled against the proof of C2 in K_t, for that matter.

The third reason for C2's provability under the assumptions of the C-tenser comes from an unvoiced assumption: there is no $t' \in T$ such that for all $t'' \in T$ either $t' = t''$ or $R(t',t'')$, i.e., there is no "beginning of time". Hereafter, I will take the "beginning of time" to refer to such a t', which I will hereafter indicate by "t_b". When I refer to the beginning of time I am affirming the existence of t_b, and when I refer to the lack of a beginning I am denying the existence t_b. Consider Table 5.3:

Members of T →	...	t'	t''
p	...	f	f
p	...	u	u
-p	...	s	s
Pp	...	?	u
-Pp	...	?	s
P-p	...	?	s
-Pp → P-p	...	?	s

Table 5.3

The breaks in the table and the columns being headed by the labels t' and t'' are to leave the existence of t_b ambiguous. I have left certain compartments with question marks to indicate the values in question. I will consider two cases in turn: (1) there is a beginning in time, and (2) there is no beginning in time.

4.1.1 t' AS THE BEGINNING OF TIME

If t' is the beginning of time, i.e., t' = t_b, then there were no times in the past where "p" was the case. Therefore, "Pp" is unsatisfied. If "Pp" is unsatisfied, then -Pp. Moreover, if there were no times in the past, then there were no times where -p. Thus, "P-p" would be unsatisfied. Since "-Pp" is satisfied and "P-p" is unsatisfied, we have a counterexample for C2.

4.1.2 t' IS NOT THE BEGINNING OF TIME

If t' is not the beginning of time, i.e., $t' \neq t_b$, then there are two possibilities for the truth-values of "Pp". If "p" was unsatisfied at all times in the past, then "Pp" would be unsatisfied. Therefore, -Pp. Moreover, "-Pp" is satisfied if and only if "p" was unsatisfied at all times in the past. For, if "p" was satisfied at some time in the past, then "Pp" would be satisfied, and thus "-Pp" would be unsatisfied. Now, if "p" was unsatisfied at all times in the past, then "-p" was satisfied at all times in the past. Thus, "-p" was satisfied at some time in the past. Therefore, P-p. Thus, if -Pp, then P-p. Therefore, if $t' \neq t_b$, then C2 holds at t'.

In fact, no counterexample is obtained without a beginning in time. Suppose that T was the set {...,t''',t',t''}, where R(t''',t') and R(t',t''). Then Table 5.3 would only represent a finite segment of an infinite interpretation (infinite in the sense that there were an infinite number of members of T such that for each $t' \in T$, there is a t'' such that R(t'',t')). Therefore, given my proof above, C2 would be satisfied at each member of T. Therefore, with the stipulation that there is no beginning in time, C2 would be logically true.

4.2 TWO MORE RESULTS OF APK_t AND COMPREHENSIVE OBJECTHOOD

Not only would the P-tenser criticize APK_t for its allowing C2 to go through under certain conditions, but he would also criticize it for allowing the conditional HP→ to go through and versions of the tense logic equivalents of the Barcan Formula, BFP and BFF, to go through. As a reminder, the wffs are:

HP→ -HA → P-A

BFP P(Σv)A → (Σv)PA

BFF F(Σv)A → (Σv)FA

I will address each in turn

4.2.1 THE CONNECTIVE "H"

Recall that Prior denies HP→ on the following intuitive grounds. Suppose that it is not the case that it has always been the case that A, i.e., -HA. One situation that would make that true would be if there were no facts about the subjects of "A" at any time in the past (although there may be facts about them presently). In such a case -A never was the case either. So "P-A" is falsified.

Prior formalized this result in QQK_t. A formula is unstatable, the reader will recall, when it has nonreferring subjects. Therefore, "A" has always been unstatable relative to an interpretation <t,T,R,P,V,D> when it had nonreferring subjects for all t',t'' ∈ T such that R(t'',t'). However, "-A" was also unstatable for all t''. Thus, at no t'' was "-A" verifiable, i.e., "P-A" gets falsified at t'. Therefore, since "-HA" is verified while "P-A" is falsified, the conditional HP→ can be falsified, i.e., it is not logically true. A little logic will show that the standard definition for the connective H fails. This proof relies on the unstatability of "A" at some time in the past. As I showed earlier, if "A" was always statable, then "-HA" is verified if and only if "P-A" is verified. Thus, Prior added the connective "Y" and redefined "H" as the conjunction of "YA" and "-P-A".

However, such situations cannot obtain given the assumptions of APK_t. The criticism Prior levels against HP→ relies on the possibility

that a wff can be unstatable, that is, some of its subjects do not exist. Since all objects exist for the C-tenser, the C-tenser does not maintain any such apprehension. Therefore, since Cocchiarella was unconcerned with this problem, he did not build a solution into APK_t. Since no situation occurs in APK_t analogous to that in QQK_t, the C-tenser defines the connective "H" in the same way that it is defined in K_t, that is:

$$H_{df} \quad HA =_{df} -P-A.$$

Thus, a little logic shows that HP→ is logically true.

This is an example of a formula which can only hold if one accepts either CO or nominalism. Since the C-tenser rejects nominalism, HP→ can only be logically true, then, when all wffs are statable, that is, when all of their subjects exist regardless of temporal location, which in turn implies CO. Thus, this is an important difference between QQK_t and APK_t.

4.2.2 BARCAN FORMULAS

BFP and BFF both hold in the quantified version of K_t since quantifiers range over *possibilia*. This is not the case in APK_t, since actual quantifiers do not range over *possibilia*. Thus, a counterexample like the one under QQK_t can be constructed under APK_t for BFP. Consider Table 5.4. Let e("x") = Socrates.

Members of T →	1	2
P	{Socrates}	
M	{<Socrates>}	
D	{Socrates}	{}
Mx	s	s
PMx	u	s
(Σx)Mx	s	u
P(Σx)Mx	u	s
(Σx)P(Mx)	u	u
P(Σx)Mx → (Σx)P(Mx)	s	u

Table 5.4

Appropriate changes can be made to provide a counterexample for BFF.

However, consider the formulas obtained when the possible existential quantifiers are substituted for actual quantifiers in BFP and BFF. Call the new formulas BFP' and BFF':

BFP' $P[\Sigma v]A \rightarrow [\Sigma v]PA$;

BFF' $F[\Sigma v]A \rightarrow [\Sigma v]FA$.

BFP' and BFF' contain the existential possible quantifier, which ranges over all *possibilia*, just as the (actual) existential quantifier in K_t does.

The counterexample in Table 5.4 does not hold for BFP'. Consider Table 5.5.

Members of T →	1	2
P	{Socrates}	
M	{<Socrates>}	
D	{Socrates}	{}
Mx	s	s
PMx	u	s
[Σx]Mx	s	s
P[Σx]Mx	u	s
[Σx]P[Mx]	u	s
P[Σx]Mx → [Σx]P[Mx]	s	s

Table 5.5

Not only does the counterexample not hold, but BFP' can be shown to be logically true in APK_t. Suppose that some instance of "P[Σv]A" is satisfied and the corresponding instance of "[Σv]PA" is unsatisfied, under an interpretation <t,T,R,P,V,D>. If the instance of "P[Σv]A" is satisfied, then at some t' ∈ T such that R(t',t), there is some individual e("x") ∈ P such that e satisfies "A" relative to <t',T,R,P,V,D>. If e("x") ∈ P in the interpretation <t',T,R,P,V,D>, then e("x") ∈ P in the interpretation <t,T,R,P,V,D>. If the corresponding instance of "[Σv]PA" is unsatisfied, then there is no e("x") ∈ P that satisfies A under <t',T,R,P,V,D>, where R(t',t). However, that is a contradiction. Therefore, BFP' is logically true. An analogous proof can be given for BFF'. Although the P-tenser would praise the C-tenser for denying logical truth to BFP and BFF, he would criticize the C-tenser for asserting the logical truth of BFP' and BFF'.

The C-tenser's affirmations of the Barcan Formulas, C2 (under certain assumptions), HP→, and the standard definition of the connective "H" rely on their affirmation of CO. CO, in turn, directs us to a consideration of the physics of time. At this point, then, I will turn to an examination of APK_t with respect to the physics of time.

5 APK_t AND THE PHYSICS OF TIME

In Chapter 2 I argued that SR is consistent with a dynamic theory of time. However, if Dt, then SR imposes a severe limitation in that only one object can be taken as existing, relative to a spatial temporal frame. I argued in Chapter 4 that the P-tenser lapses into solipsism. Therefore the set D(t) of the interpretation <t,T,R,P,V,D> is limited to one object, thus allowing quantification only over that one object.

This argument rests on the here-now of SR. Therefore, even if a neo-Eleatic view of time is correct, analogous, but not identical, conclusions may follow for the C-tenser! Given the here-now of SR, there can only be one member of D(t). Therefore, internally, that is, relative to an interpretation, the C-tenser is a temporal solipsist. In the strict sense, however, the C-tenser is not a solipsist, for everything exists externally: the C-tenser is not an external solipsist. Nonetheless, this internal solipsism leads to problems for the C-tenser.

In section 5.1 I will present a dilemma faced by the C-tenser on account of his internal solipsism. In sections 5.1.1-5.1.2 I will address the first and second horns of the dilemma. The dilemma also suggests a problem in the relationship between the sets D(t'), for all t' ∈ T, and P. In section 5.2.1 I will briefly entertain the

possibility of a more comprehensive comprehensive objecthood. In section 5.2.2 I will examine the relationship between D(t')s and P.

5.1 THE SOLIPSISM OF THE QUANTIFIERS

The "temporal solipsism" implied by Putnam's neo-Eleatic argument imposes the following dilemma on the C-tenser: either the set D(t) of <t,T,R,P,V,D> is indistinguishable from the set P or the set D(t) and all other D(t')s (for all t' $\in$ T) have one and the same member. This dilemma, coupled with various properties of the relationship between all D(t')s and P, implies that either actual quantifiers yield results indistinguishable from their possible counterparts or the differentiation of possible from actual quantifiers in APK_t leads to a solipsism for actual quantifiers, just as those in QQK_t. Moreover, the second horn of the dilemma leads to results logically equivalent to those of the first horn. I will treat each horn in turn.

5.1.1 THE FIRST HORN

Cocchiarella distinguishes possible from actual quantifiers according to the domains over which they range: actual quantifiers range over the set D(t), while possible quantifiers range over the set P. If he does not want actual and possible quantifiers to be equivalent, then D(t) must not have the exact same members as P. For, if these two sets are indistinguishable, *actualia* and *possibilia* are indistinguishable. Since *actualia* and *possibilia* would be indistinguishable, the objects which actual and possible quantifiers range over would also be exactly the same objects. Therefore, actual quantifiers would be interchangeable *salva veritate* with their possible counterparts, and

vice versa. Therefore, "$(\Sigma x)A$" is satisfied if and only if "$[\Sigma x]A$" is satisfied, and "$(x)A$" is satisfied if and only if "$[x]A$" is satisfied. Given the distinctions exemplified in sections 3.1-3.1.1.3, this cannot be what Cocchiarella is after. So, the first horn of the dilemma would be unacceptable to the C-tenser.

5.1.2 THE SECOND HORN

If we are to maintain a distinction between actual and possible quantifiers, then conditions must hold which allow D(t) to be a proper subset of P. Therefore, Cocchiarella defines the set D(t) as the set of all present existents and the set P as the set of all existents, past, present, and future. However, SR implies that the set D(t) consists of one member. In section 3.2.3 I distinguished internal and external existence. Roughly speaking, something exists internally to an interpretation if and only if it is a member of the set D(t); on the other hand, something exists externally to an interpretation if and only if it is a member of the set P. (Therefore, every internally existing object possesses external existence.) Applying such vocabulary to this situation, APK_t falls into an internal present-point solipsism (IPPS). Internally, only one thing exists over which actual quantifiers range. Therefore, with IPPS comes limitations of PPS for APK_t's actual quantifiers: they become virtually useless.

Moreover, with such a limitation, and the added assumption that D(t) is not empty, the universal and existential actual quantifiers yield equivalent results. For if there is only one thing which can satisfy a wff containing actual quantifiers, then if that one thing does, then all things available to actual quantifiers do. Therefore,

any wff A prefixed by the existential actual quantifier will be equivalent to A being prefixed by the universal actual quantifier, that is, "(Σx)A" is satisfied if and only if "(x)A" is satisfied.

Now, I have characterized D(t'), for all t' $\in$ T, as a subset of P. Moreover, I have characterized P as the union of all sets D(t'). However, consider SR again. SR suggests that if we are to take each D(t') to be distinguishable from P, then D(t') must be a set with one member, and P contains all existents. Moreover, each D(t') would always consist of the same member, just as in QQK_t. From the assumption that P is the union of all sets D(t'), P would only consist of one member. Thus, P would become indistinguishable from each D(t'), and therefore, D(t). We return to the first horn of the dilemma. In short, the sets must be indistinguishable, given Cocchiarella's definitions and SR.

5.2 SOLIPSISM AND A MORE COMPREHENSIVE COMPREHENSIVE OBJECTHOOD

My argument that the sets D(t') and P are indistinguishable rests in part on the assumption that P is the union of all sets D(t'). In sections 5.2.1 and 5.2.2 I will entertain the possibility of denying this assumption. In section 5.2.1 I will briefly address a more comprehensive CO than the CO for which the neo-Eleatic argues. In section 5.2.2 I will define P as the set of all objects tenselessly existing, in line with the neo-Eleatic view. I will point out the limitations of both assumptions.

5.2.1 A MORE COMPREHENSIVE COMPREHENSIVE OBJECTHOOD

As I have laid it out, Cocchiarella takes *possibilia* to be the set of all individuals which existed in the past, exist currently, or will

exist in the future. Despite the temporal qualifications on them, he takes all individuals to exist in the neo-Eleatic sense. Therefore, I argued above, he accepts a form of CO. However, he also entertains a *more* comprehensive CO: things which could exist, but never have existed, do not exist, and never will exist, i.e., a use of the words "possible existents" more in line with their ordinary language use. Such a set would be a true logic of *possibilia*.

There are two basic problems with such a view which derail any extensive consideration of it in this essay. First of all, it seems even more radical than many conservative de-tensers would accept (Massey 1969, 21). *Prima facie*, here is a place where the "nominalistic fears" of many are not "allayed". Secondly, I take it as an assumption of this essay that nominalism is unacceptable for a tense logic. Therefore, to address this consideration either oversteps the bounds of acceptable ontology or, at least, oversteps the assumptions of this essay.

5.2.2 *POSSIBILIA* AND NONPRESENT EXISTENCE

Despite the fact that Cocchiarella considers an ontology more radical than we can consider here, there may be a sense in which we can entertain the notion that an object x never existed, does not exist, and never will exist in the present of another object y, yet is an existent in the external sense, thus making x a candidate for the set P, although never a member of any D(t'), for any t' $\in$ T. To consider this possibility, we need to look to the sets D(t') and P again.

Suppose that we do *not* take P to be merely the union of all D(t')s. Suppose instead, that P can include objects which are never members of any D(t'), but that exist in some sense. They would exist in

the tenseless sense. In that case, there would be objects which have never been members of any D(t'), yet could be quantified over using possible quantifiers. Taking this option, all the members of P would exist *externally*, dispelling any concerns of quantification over nonexistents.

However, this will not do, for they never exist *internally*. If they never exist internally, they cannot be the subject of any satisfied wff, unless one of two things happen: either the wff contains negation symbols or does not contain actual quantifiers. The former makes a satisfied wff possible since a satisfied negation of a wff is the negation of an unsatisfied wff. The latter makes a satisfied wff possible because possible quantifiers range over objects which may not be members of D(t'). Either option would be a weakening of tense logic. The first option weakens the logic for obvious reasons: we do not merely want wffs to be satisfied when they contain negation symbols. Although a logic might be developed which could express everything we wished (maybe by making every assertion the negation of its denial), it would be awkward in its translations, and thus subject to some of the criticism leveled against QQK_t.

The reasons the second option weakens APK_t are apparent from APK_t's evaluation rules for the tense connectives: evaluation rules for tensed connectives make reference to other sets D(t'). Consider, for example, the wff "$P(\Sigma x)Mx$". The evaluation rule for the past tensed connective "P" requires that at some time in the past there had to be an x, existing in the D(t'), where $t' \in T$ and R(t',t), relative to that interpretation <t,T,R,P,V,D>, which M's. Given SR, only one object

could fit that description and that object has to be the same object that is the sole member of D(t'). Clearly this is undesirable.

6 CONCLUSION

Until now I have evaluated APK_t relative to the neo-Eleatic position on the physics of time, that is, on its own grounds. Given my argument in Chapter 2 things are much worse for APK_t. If my view of time is correct, then some sort of tense logic would seem appropriate. However, the question of whether APK_t is adequate is difficult to answer. Cocchiarella did not devise APK_t with an eye to dynamic time. In fact, his ontology may be much more robust than some neo-Eleatics. The question becomes, however, would APK_t be adequate for the conservative ontology of a dynamic theory of time?

I believe not for two reasons. First of all, possible quantifiers range over nonexistents, in the strict sense. So APK_t quantifies over nonexistents. Clearly, this is unacceptable. Secondly, while APK_t allows for the denial of the tense logical Barcan formulas, BFP and BFF, as we saw in sections 4.2.2, it denies neither the other tense logic versions of the Barcan Formula BFP' and BFF' nor the interdefining of the connectives H and P, as we saw in section 4.2.1.

Based on the discussions in Chapter 2, it seems that APK_t is inadequate. If these arguments are correct, then it is not clear that the C-tenser provides us with a useful logic, relative to ontologically interesting questions. Moreover, even if the C-tenser and de-tenser are correct in their ontological assumptions, APK_t suffers from IPPS and is thus rendered practically indestinguishable from standard predicate logic.

CHAPTER 6

CONCLUSION

1 INTRODUCTION

This essay was organized by four guiding considerations: temporal ontology and its relation to special relativity; temporal ontology's implications for tense logic in general; temporal ontology's implications for two particular types of tense logical systems; and evaluations of those two types of tense logic as logical systems in themselves. In this chapter I will briefly outline the possible views and restate the conclusions that I drew. The outline will be organized according the the four guiding considerations. The conclusions leave the discussion unresolved, however, for although I find a the P-tense approach preferrable there are problems with both it and the C-tense approach. After I have reviewed these issues, I will propose some possible routes for resolution of the overall problems.

2 A BRIEF OUTLINE AND SUMMARY OF VIEWS

2.1 TEMPORAL ONTOLOGY AND SPECIAL RELATIVITY

One may choose to take time as either (1) neo-Eleatic or (2) dynamic. There are many avenues of discussion on this topic. I chose to take the route based on discussions of SR, as it is a primary basis on which Massey and Quine criticise the tense logic project in general.

They argue that since SR takes time as space-like, past and future objects share their ontological status with present objects. This typifies option (1). The results for tense logic fall from such a view. Quantification over past and future objects is legitimate. Thus, nothing more than standard predicate logic is necessary to adequately treat assertions about nonpresent individuals. Moreover, they continue, the complications of tense logic make it an undesirable route.

In opposition I chose option (2). I argued that SR is consistent with a dynamic theory of time. Moreover, I argued that experience suggests that time is dynamic; and without some other compelling grounds, we should take time as dynamic. I went on to suggest some implications of SR for the notion of a transient Now. The transient Now, if there is one, must have the following characteristics. First of all, it is not an entity, but should be conceived of as a relationship: it is the border between past and future objects and/or events. Thusly, it defines the present. Secondly, the Now is conceived of as a point-instant in SR. All present existence is defined by the Now. The significance of this claim cannot be understated. It plays a central role in later chapters.

2.2 TEMPORAL ONTOLOGY AND TENSE LOGIC

Under the second consideration I argued that a dynamic conception of time suggests the desirability of the development of temporally sensitive logic. Two possible types of tense logic were defined, (1) P-tense logic and (2) C-tense logic. The P-tenser, exemplified by Prior, takes the dynamic theory of time as its jumping off point. In particular, Prior was motivated by various tense logical and modal

logical formulas to examine temporal ontology as a set of guiding considerations in the development of a more sensitive tense logic. Thusly, he ended up with his tense logic system QQK_t.

Cocchiarella, on the other hand, exemplified the C-tense logician. His motivation seemed to be a general interest in the development of a tense logic modeled on contemporary developments in modal logic. This resulted in tense logic sensitive to the temporal implications of tense. However, it was not sensitive to the ontology of dynamic time. Thus he set up a system assuming a robust view of ontology and consistent with the dominant view of time as purportedly informed by SR.

2.3 TEMPORAL ONTOLOGY FOR THE P-TENSER AND C-TENSER

I argued that there were two sets of problems which the C-tenser faces. First of all, the assumption of neo-Eleatic time is misguided. Therefore, the C-tenser's robust ontology leads to tense logic which quantifies over nonexistents, something he claims not to want to do. However, even if his robust ontology is well-founded, the conception of the Now *which SR implies* results in either, (a) the indistinguishability of the so-called actual and possible quantifiers, or (b) the mistaken definition of the sets P and D(t), of an interpretation <t,T,R,P,V,D>. Either way, we can see that the C-tense approach faces serious problems. I will return to these concerns later in this chapter under the discussion of a change in conception of the Now.

If the dynamic view of time is correct, then, the P-tenser approach is preferrable. However, it even faces severe limitations. In particular, it shares the problems of present-point solipsism (PPS) and world-line solipsism (WLS) with the C-tenser approach. PPS is the

conclusion that quantification for the actual quantifiers is limited to a single individual. WLS is the conclusion that at every instant in the past and future there is only one object that may be used in quantification.

2.4 THE TENSED SYSTEMS EVALUATED ON THEIR OWN MERITS

The last of the guiding considerations concerns the evaluations of these systems in themselves. The P-tenser system QQK_t faced many problems, the most considerable of which is the problem of definition in particular translations. Since QQK_t does not allow the simultaneous quantification over individuals which exist at different times, expressing relationships between noncontemporary individuals becomes awkward. I do not mean here awkward in the sense of complicated. I mean, that it becomes awkward based on theoretical considerations of definitions and/or the implications of SR. Moreover, it leads to the analytic truth of facts which should be empirical. I will not rehash these considerations here, but suffice it to say that the complications seem to me insurmountable.

APK_t fares much better on its own logical terms. It does not break any rules of semantics or logical systems in general. The only concerns one must face are those of the assumptions based on SR. I briefly addressed those concerns in the previous section. I will take this problem, the problem of temporal solipsism, as the spring board in this chapter. I will present possible solutions and map out the territory. But I will not defend any particular solution.

2.5 SUMMARY

In summary, one may either be a tenser or a detenser. The tenser argues that a tense logical system is, at the minimum, a desirable addition to standard predicate logic. The tenser is exemplified by both A.N. Prior and Nino Cocchiarella. The detenser argues that tense logic is undesirable. The detenser is exemplified in this essay by Quine and Massey. Within the tenser tradition we have the P-tenser and the C-tenser. The P-tenser takes time to be dynamic and thus produces a tense logic in accord with the concerns of a tensed ontology. The C-tenser, on the other hand, agrees with the detenser in taking time to be neo-Eleatic. Thus, the C-tenser is not concerned with the issues of tensed ontology in quite the way in which the P-tenser is. Both the C-tenser and P-tenser face solipsistic complications based on the notion of the here-now in SR. However, while this leaves the P-tense system virtually useless, the C-tense system becomes more like a standard predicate system. Now I wish to move on to possible resolutions to the solipsistic problems posed by SR's implication for the here-now.

3 THE PROBLEM OF SOLIPSISM

The problem of solipsism results from two considerations: firstly, the concept of the Now or here-now in SR is defined by a spatio-temporal point instant; secondly, both QQK_t and APK_t define the sets P and D(t) (of $<t,T,R,P,V,D>$) such that P is made up of all the members of sets D(t'), for all $t' \in T$. The first concern is driven by the following set of questions. What does it mean to say that the present is defined by such a point? What is included at that point? SR makes use of the *theoretical infintessimal* point. But how small are we to take the

actual point to be? The problem can be framed by the following image. Those who argue that the here-now defines the present employ diagrams with other events or objects being somehow outside of the present. They say that things within the present and things outside of the present and not in the past or future lightcones have *space-like separation*. But, what are these things? If one takes things to be objects, then, for example, do two galaxies have space-like separation; two solar systems; two planets; continents; cities; people; internal organs; cells; etc.? Appropriate examples can be given for events also. This may seem like a simple-minded question. But if we need to decide which objects may be quantified over, and we feel that SR informs us on this, as many critics of tense logic maintain, then this question must be answered.

Moreover, because the resolution to this problem may imply that the present must contain only one thing, the set D(t) may contain only one object. But if that is the case, tense logical formulas containing only actual quantifiers can only quantify over one object. Such a result utterly devistates QQK_t since it only uses actual quantifiers; and it renders APK_t trivial, since actual quantification, i.e., quantification with actual quantifiers, is useless, and quantification with possible quantifiers may be shown to be fundamentally equivalent to quantification in standard predicate logic.

The second consideration is closely connected to the first consideration. At this point the reader should call to mind the general form of Minkowski diagrams containing future and past light-cones. Clearly, there can be more things existing in the past (future) than ever actually existed (will exist) at past (future) here-nows, such as all things within the past (future) lightcone, regardless of how many

objects we accept into the set D(t). So, it seems, we would want to take the set P to be not merely the set of objects existing at every past, present, and future here-now. But, that is not how the relationship between the sets is defined. Can this definition be refined? I will discuss this point first. In later sections I will entertain different considerations of ontology.

4 PAST, PRESENT, FUTURE, AND THE SETS P AND D(t)

As presented in Chapters 3 and 5, both QQK_t and APK_t take the set P to contain all and only those objects which are members of D(t'), for all t' $\in$ T, under an interpretation <t,T,R,P,V,D>. Therefore, P = D(t') + D(t'') + ..., for all t',t'',... $\in$ T. In other words, P is to contain all and only those objects which have been or will be in the present relative to some here-now.

However, applying the concepts of temporal ontology as defined by SR severly limits the possible members of the sets D(t') and P. Consider Figure 6.1:

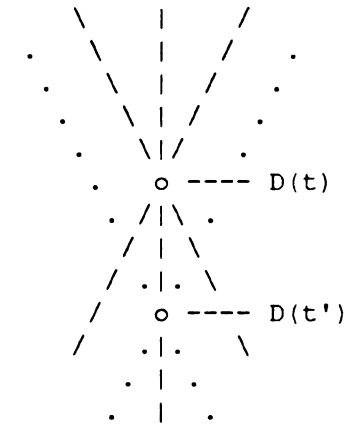


Figure 6.1

Figure 6.1 depicts the situation as defined in the presentation of the tensed systems in this essay. The sets D(t') are sets with members that exist at some spatio-temporal here-now, but they cannot exist at other spatio-temporal positions. The fall out is that the sets D(t') and the set P are severly limited in their possible members. For example, things in past and future lightcones, but not on a world line, are not part of any D(t'). Moreover, such considerations at least apply to the sets D(t') regardless of whether one holds a dynamic or neo-Eleatic view of time.

If the tenser wishes to maintain the viability of tense logic, then she is going to have to resolve this problem by either adjusting her tense logic or adjusting the accepted view of temporal ontology as informed by SR. I will spend the remainder section 4.1-4.2 entertaining the first alternative. I will return to the second alternative in sections 5-5.3.

4.1 CHANGING THE TENSE LOGIC

There are three possible ways of changing the tense logic. The first would be to allow that the set P contain members that never have and never will be members of any D(t'). This can be done in two ways, both of which I considered in Chapter 5. The first was to allow objects which never exist in the strict sense. I dismissed this out of hand on the grounds that it takes us into considerations beyond the scope of this inquiry. The second option is that all sets D(t') contain only members that exist at points of the world-line of the Minkowski diagram representing the universe applicable to the interpretation, while P contains members that do not exist in any D(t'). That led us to the

quantifier dilemma discussed in Chapter 5, viz., either the actual quantifiers range over a very limited set, in which case many members of P can never be quantified over using the actual quantifiers, or the actual quantifiers and possible quantifiers yield equivalent results.

For the third option, consider Figure 6.1 again. The problem was that all sets D(t') consist of members existing at some point on the world-line of the thing at the here-now. But consider Figure 6.2:

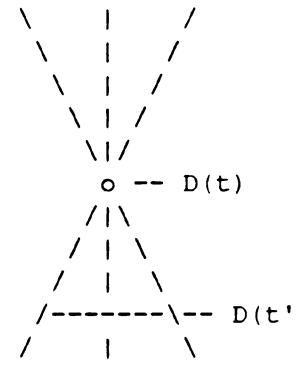


Figure 6.2

Suppose that the sets were redefined in such a way that the sets for past and future existents could contain objects not in the present of any point on the world-line, that is, not present to any here-now of the world-line, but which exist orthoganally to the spacial dimensions and within a light-cone. In such a scenario, quantification over past and future members of P could obtain, for both C-tensers and P-tensers. To remain true to the P-tenser view, quantification must take place embedded within past and future operators. The same would be true of the C-tenser for the actual quantifiers. However, quantification using possible quantifiers would be greatly enhanced, for the set P would grow tremendously.

4.2 FURTHER CONSIDERATIONS ON CHANGING THE TENSE LOGIC

The changes outlined in the previous chapter suggest to me another possible route of resolving the problem of present-point solipsism. It seems strange to say that we can include objects in the sets D(t') that pick out future existents, not include those objects in the set D(t), and then include them in some sets D(t') that pick out past existents. In other words, how is it possible that something exists in past and future light-cones, but does not exist at the present? This seems like a route worth investigating. There is one qualification: such a resolution would face fewer complications if we were to take objects as ontologically relevant; if we were to take events as ontologically relevant, then what is taken as the possible duration of an event itself is relevant, a complicated consideration.

5 FURTHER CONSIDERATIONS ON CHANGING THE TENSE LOGIC

Now that I have laid out the possible routes for resolution of these problems via changes in the tense logical systems, I wish to consider possible changes to our conception of SR. In particular, I want to consider the notion of "simultaneity", as it defines that which is possibly present to a particular here-now. I will address this consideration in three sections. First of all I will consider the notion of *topological simultaneity*. Secondly, I will consider the fact that we *may* know what will exist in the future and what existed in the past. That may give some clues as to what we can take to be simultaneous to a here-now, regardless of the fact that it has space-like separation from a particular here-now. Thirdly, I wish to consider the idea of defining *local simultaneity*.

5.1 TOPOLOGICAL SIMULTANEITY

SR takes two things to be topologically simultaneous if and only if they cannot be connected by signals traveling at or below the speed of light. Therefore, topologically simultaneous things cannot be causally connected. Things at the here-now are topologically simultaneous to everything outside of its light-cones. Topological simultaneity is depicted graphically in Figure 6.3:

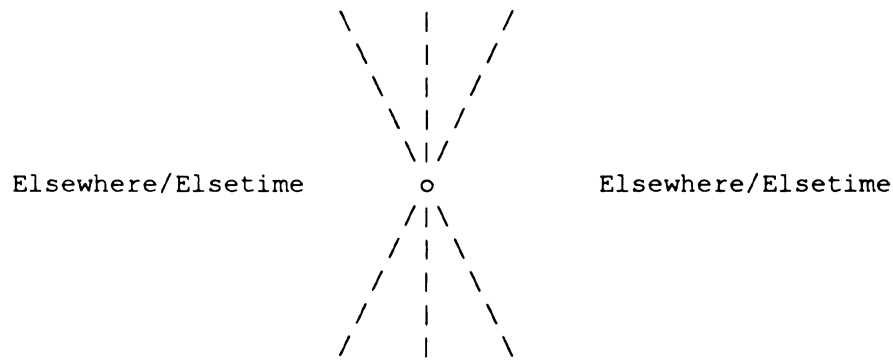


Figure 6.3: Topological Simultaneity

Now, it may be noted that two things can be topologically simultaneous relative to one point on the world-line, but not relative to another. Such is the case depicted in Figure 6.4:

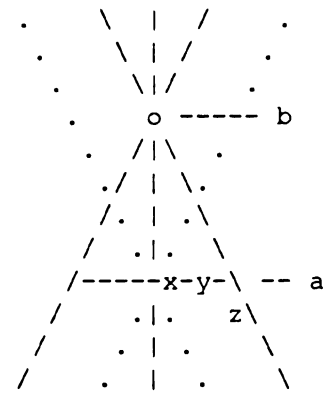


Figure 6.4

Notice that relative to the here-now *a*, x, y, and z are topologically simultaneous. However, relative to the here-now *b*, they are not. In fact, relative to *b*, both x and y can be taken to have existed simultaneously to *b*, and z was temporally prior to *a*, x, and y.

5.2 DENYING OCHAM'S RAZOR

The results of SR come in part because of certain verificationist assumptions. For example, one cannot pick out a privileged inertial frame to establish a privileged temporal order. Therefore, SR assumes that there is not one. There is another example in which it works, viz., the establishing of absolute simultaneity: no two events can be established as absolutely simultaneous since, again, an absolute reference frame cannot be picked out in order to de-relativize simultaneity. But there is also another example, which bears directly on the considerations of this chapter. Two space-like separated events cannot be determined to be simultaneous relative to one or the other event. Simultaneity can only be established relative to a particular here-now which may or may not exist on the world-line of one or other of the events. This can be seen by considering Figure 6.3 again.

The relevance of this and the previous results for this chapter is to establish the existence of the objects for the set D(t): they would be the objects of the events to which I am refering. In the future it will be known what is presently simultaneous, even if the Now which I outlined in Chapter 2 cannot establish that relationship. The possible solution for tense logic lies in this consideration. It may be possible to establish present existence via interpretations of past and future here-nows, or in other words, via interpretations relative to different members of the set T of an interpretation. This route seems promising to me.

5.3 LOCAL SIMULTANEITY

The final possible route of resolution which I will suggest is that of local simultaneity. Two events E and E' are *locally simultaneous* if and only if they occur at approximately the same time and place. Such a conception can only result if we take the present to be defined by something other than an actual physical point. It must be something of a finite size. Such a consideration is depicted in Figure 6.5:

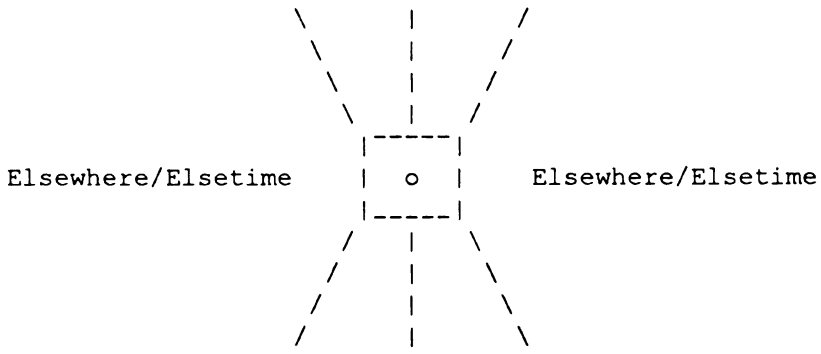


Figure 6.5

Notice that I have represented this with two types of shadings. This represents two possible routes for defining the present. First, the present may be defined using signals traveling at the speed of light, but not including the area defined as space-like separated from the here-now point, although within the spatial area defined within light-cones. Such a definition would only include the areas shaded with vertical lines. The second possibility would be to stipulate the existence of objects outside of the light-cones, but within the spatial area defined by luminal velocity. Such a definition would include those areas of the former definition and those shaded with the horizontal lines. The second option seems to me in greater opposition to the discussion in Chapter 2 about the existence of things in the "elsewhere" area. However, since the former option does not fly so blatantly in the face of that discussion, it seems more promising. Let's consider that option.

The first option is accomplished by picking some duration and stipulating that everything that is time-like separated from the here-now within that duration exists presently. In other words, anything which falls within the area of past and/or future light-cones over a

certain duration will be taken as existing presently relative to that particular here-now. The problem, however, would be picking some small, *nonarbitrary* duration to define the space allowed to establish said present existence.

If that duration were one second, then the area of present existence would be defined by a sphere with the radius of 186,000 miles and the center at the here-now point. That would certainly be rather large, and would allow most predication one may desire within a tense logic system. But the choice of one second as the duration seems very arbitrary. It seems to me that there should be *physical significance* to the time period picked. For example, as Heisenberg's uncertainty principle comes into play at about 10^{-43} second some have taken this to be the smallest meaningful duration. But that would define an extremely small sphere, a sphere with a radius of 1.8×10^{-38} miles, to be exact. That would hardly be any better than an infintessimal point, for our purposes.

The next obvious (to me) option, would be the smallest perceivable duration for humans, or in other words, the *specious-present*. That duration, although I do not know what it is, may be too small, also, however. For consider how quickly the radius diminishes. One tenth of a second knocks the radius down to 18,000 miles. This may not be too damaging, for at least the whole earth would be within the radius. But if the specious-present is one-hundredth of a second, then the whole Earth would not be within the radius. If we were going to pick a number, we should hope that it produces a radius for the sphere of present existence at least great enough to include the entire Earth within the present. That would take a duration somewhere in the range

of four-hundredths of a second, as that is about the amount of time for light to cover a distance equal to the diameter of the Earth.

6 CONCLUSION

The solution to the problem of tense logic, then, will have to include some account of time which is faithful to the physics of time. I have given a solution to this part of the problem in this essay. I have argued that time is dynamic; therefore, a logic sensitive to the corresponding temporal ontology is necessary. That logic would have to be of the P-tense variety. For unlike the C-tenser, the P-tenser attempts to come to grips with the limited ontology of dynamic time. However, the P-tenser has problems of translation to work out. Moreover, P-tenser will have to arrive at a solution to the problem of the Now of SR: if he is to remain true to science, the locality of the Now needs to be solved.

LIST OF REFERENCES

Aristotle. *Physics*. W.D. Ross, trans. (Oxford: Clarendon Press, 1960).

Augustynek, Zdzislaw. *Time: Past, Present, Future*. Stanislaw Semczuk and Witold Strawinski, trans. (Kluwer Academic Publishers: Dordrecht, 1991).

Black, Max. "Review of G.J. Whitrow's *The Natural Philosophy of Time*". *Scientific American*, CCVI (April 1962), 181-182.

Capek, M. "The Inclusion of Becoming in the Physical World". *The Concepts of Space and Time: Their Structure and Their Development*. M. Capek, ed. Boston Studies, 22. (Dordrecht, Holland: D. Reidel Publishing Co., 1976), 502-520.

---. "The New Aspects of Time: Its Continuity and Novelties". Boston Studies in the Philosophy of Science, 125. (Dordrecht, Holland: Kluwer Adademic Publishers, 1991).

Cocchiarella, Nino B. *A Study in Temporal Ontology*. Doctoral Dissertation (1966).

Dieks, D. "Discussion: Special Relativity and the Flow of Time". *Philosophy of Science*, 55 (1988), 456-460.

Eddington, Sir Arthur. *The Nature of the Physical World*. (USA: U of Michigan P, 1963).

---. *Space, Time and Gravitation*. (Cambridge: Cambridge UP, 1921).

Findlay, J.N. "Time: A Treatment of Some Puzzles". *The Philosophy of Time*. Richard M. Gale, ed. (London: MacMillan, 1968), 143-162.

Grunbaum, Adolf. *Philosophical Problems of Space and Time*. (Boston: D. Reidel, 1973).

Kripke, Saul. "Semantical Considerations on Modal Logic". *Acta Philosophica Fennica*, (1963), 83-96.

Massey, Gerald J. "Tense Logic! Why Bother?" *Nous*, III.1 (Feb.1969), 17-32.

Maxwell, N. "Are Probabilism and Special Relativity Incompatible?" *Philosophy of Science*, 52 (1985), 23-43.

---. "Discussion: Are Probabilism and Special Relativity Incompatible?" *Philosophy of Science*, 55 (1988), 23-43.

Miller, Fred D., Jr. "Aristotle on the Reality of Time". *Arch. Gesch. Phil.*, 56 (1974), 132-155.

Øhrstrøm, Peter and Hasle, Per. "A.N. Prior's Rediscovery of Tense Logic". *Erkenntnis*, 39 (1993), 23-50.

Prior, A.N. *Time and Modality*. (Oxford: Clarendon Press, 1957).

---. *Past, Present and Future*. (Oxford: Clarendon Press, 1967).

---. *Papers on Time and Tense*. (Oxford: Clarendon Press, 1968).

Putnam, Hilary. "Time and Physical Geometry", *Journal of Philosophy*, LXIV (1967) 240-247.

Quine, W.V. *Word and Object*. (Cambridge, Mass.: MIT Press, 1960).

Reichenbach, Hans. *The Direction of Time*. (Berkeley: U of California P, 1956).

Rietdijk, C. W. "A Rigorous Proof of Determinism Derived from the Special Theory of Relativity". *Philosophy of Science*, 33 (1966), 341-344.

Russell, Bertrand. *An Essay on the Foundations of Geometry*. (Dover, 1956).

Sellars, Wilfred. "Time and the World Order". *Minnesota Studies in the Philosophy of Science, Vol. III*. Herbert Feigl and Grover Maxwell, ed. (Minneapolis: U of Minnesota P, 1962), 527-616.

Sklar, Lawrence. *Space, Time and Spacetime*. (Berkeley: U of California P, 1974).

Smart, J.J.C. "Spatialising Time". *Mind* (1955), 239-241.

Smith, Quentin. "The Mind Independence of Temporal Becoming". *Philosophical Studies*, 47 (1985), 109-119.

Stein, Howard. "On Einstein-Minkowski Space-Time". *The Journal of Philosophy*, 65 (1968), 5-23.

---. "On Relativity Theory and the Openness of the Future". *Philosophy of Science*, 58 (1991), 147-67.

G.J. Whitrow's *The Natural Philosophy of Time*.

Williams, C.J.F. *What is Existence?* (Oxford: Clarendon Press, 1981).