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THE LOGICAL POSSIBILITY OF TIME TRAVEL

2 VOLUMES (VOLUME 1)

SHARON ELIZABETH NEY

PH.D.

UNIVERSITY OF DURHAM

PHILOSOPHY

1993



Sharon E. Ney

The Logical Possibility of Time Travel

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This thesis examines the logical possibility of manned, or information-carrying temporal movement into the causal past of the object being relocated. This is achieved through the application of carefully controlled thought experiments to specific problems associated with such activity, namely: contradictory claims and alternative time frames -- where the object is said to travel 100 years in 5 minutes; identity relations -- where a traveller communicates with himself at an earlier moment in time; freewill and determinism -- particularly the problem of preserving the traveller's freewill when full knowledge of future events is available (this chapter includes a brief analysis of possible worlds); causal relations -- including backward causation and time travel, and closed causal chains (this chapter includes a fuller examination of time travel and possible worlds). I conclude that whereas time travel cannot be proved logically impossible without certain physical assumptions, the required concatenation of circumstance is so highly improbable as to make organised, human-determined time travel a practical impossibility.

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DECLARATION

No part of this thesis has been previously submitted for a degree at either the University of Durham or any other institution.

Preface

When I began this thesis it was with the intention of determining whether or not the popularly conceived image of time travel (primarily into the past) could ever become a reality. This was to be done by analysing the logical structure of that concept. But what seemed, with little thought, to be so manageable a task proved impossibly complex and, towards the end, I was constantly faced with the image of myself trying to nail a cloud to the floor.

For one thing, the 'popular' image is hardly clear-cut, and I soon fell into the trap, to which other philosophers have also succumbed, of failing to define in advance precisely the system of time travel to which I referred. In fact the concept was always there subconsciously, otherwise the intensely interconnected nature of this thesis could never have been realised, but trying to formulate the concept in words that would allow no interpretation but the one intended by the author proved to be an exhausting task.

The interconnectedness itself has also posed enormous problems. In one obvious sense it is very gratifying as it ensures, I believe, that the whole is very tightly knit and that, once one point has been conceded, the rest must follow. But, as with any long term process, the pattern of argument presented here bears little resemblance to its earlier incarnations. As theories were shown to be flawed by later additions, and alternatives were prepared, so the entire work was to be constantly re-evaluated, and

appropriate alterations made. The image changed from the cloud to dominoes and back again.

The amorphous nature of the study, being centred on something as yet unrealised and which -- if these conclusions are correct -- will never be realised, has raised other problems. Spatial analogies for time are notoriously deceptive, but how else can one clearly represent temporal movement on a page? The graphs included were all necessary, because the temporally dominated nature of the English language, quite apart from any other consideration, makes discussion of the incredibly complex subject of time a necessarily verbose exercise if clarity is to be preserved. Verbosity also hampers clarity, though; hence one problem was compounded by another, and then by a third when graphical imagery was used in an effort to express in an easily understood form the concepts expressed in writing. Warning is hereby given that certain sections (most notably those in Chapter 4 concerning the freedom of a traveller in the spatio-temporal relocation of a book, and in Chapter 5 concerning anti-matter time travel) must be read with extreme care due to the excessive complexity of trying to hold four dimensions in mind at the same time (see the problem?) instead of the more usual three. It is hoped that the graphs, which are correct, will help.

Two other images have remained constant companions throughout this study. Escher's *Ascending and Descending* is an elegant graphical representation of the closed causal

chain, which is the linchpin of time travel according to the popular conception as I have defined it (see the Introduction). It is also equally frustrating and impossible to conceptualise in real terms: frustrating, because it looks so straightforward at first glance and proves so complex when studied more carefully; impossible, for the reasons outlined in this thesis. The second image is that of the Möbius band. As a representation of the confusion between occasion and experience (see Chapter 4) it is ideal, although I refrained from making appeal to it in that Chapter (an omission that I hope has been rectified by its inclusion here), and as an aid to thinking about dimension in an unusual manner it proved invaluable.

This thesis has also been the attempted realisation of a long held dream, and as such has been a dismal failure. I began with the intention of proving time travel possible, and ended by having to admit that all my efforts had failed. But this also adds to the strength of the study. My definition was intentionally wide ranging in order that anything that might be considered acceptable as an instance of time travel to 'the man in the street' would be covered, together with several alternatives with which popular opinion would not necessarily agree. Any method that might be used to resolve a particular problem was considered, although not all those considered have appeared in this final submission -- in most cases because when analysed they all reduced to something which had been included already,

but occasionally because the alternatives instantly raised more problems than they solved (ghosts, reincarnation, and spiritual relocation may be counted amongst the latter). My determination to prove time travel possible has, I believe, made my study thorough, with every effort made to disprove my eventual conclusion. Even now I still seek a way out of it.

If a preface is the place where one thanks all those who have helped, then that duty must now be performed. First I must thank all those -- whether friends, relatives, seminar audiences, tutors, or total strangers who engaged me in conversation -- who tolerated my frustrations, posed problems, and made me re-think my theories a thousand times. Specifically I include my supervisor, Jonathan Lowe, who gave me free rein in the early stages, and then imposed the required discipline on my writing without making me dejected at the enormity of the task which lay ahead. Barry Gower gave me the strength to believe in myself when, quite frankly, I didn't, and Paddy FitzPatrick restored my good humour with his own, as well as giving me, by his own academic example, a lesson in scholastic honesty that I have tried to take to heart.

Finally, a note addressed to any who consider my use of a male character for all my thought experiments an indication of sexual repression. I here point out that while it is true that Chronos features throughout these studies, in the course of the examples provided for analysis he is

revealed as a paranoid, homicidal schizophrenic! The real reason for using Chronos is that 'he' has one less letter to type than 'she' and s/he is a distraction which becomes unmanageable and clumsy when reflexives are needed.

Introduction

Section 1

Definition

How does one define time travel? Typically, the response of the man in the street differs from that of the physicist or mathematician: while the latter speak in terms of quantum or relativistic effects, the former imagines a machine with a 'time switch' carrying a human being or, at the very least, a note written by one; where physicists speak in terms of parts of a second, the layman imagines the passage of millenia; and where scientists are concerned with mathematics, the man in the street thinks of freewill and attempts made to change the past. Both are concerned with causality, but once again the non-scientific approach is generally on a grander scale. This is not to claim that science never considers these aspects, only that a more rigorous system, concerned primarily with the mathematics of the subject, is less prone to misinterpretation due to the accidental use of unacknowledged variables than the purely image-based reasoning, concerned with more human issues, which is the realm of the non-scientist. As a result, whilst images are provided to aid the understanding in many scientific studies, the real work is often done by formulae. However, the intention of this study is to determine the logical possibility of time travel as conceived in the 'popular' imagination, and from the above examples there is revealed a dichotomy between the scientific and popular



understanding which indicates that the purely scientific approach is inadequate to the task. Methods by which the disadvantages of the non-scientific approach may be overcome will be examined in due course, but first a clear definition of the system of time travel to be examined must be provided, since it will have a profound effect on both the structure of this thesis and the validity of the conclusions drawn.

It is interesting to note that although many articles have been written about time travel, few concern themselves with defining in advance precisely what is meant by the term. The 'closed time-like loops' and 'movement into the backward light cone' of the physicist's definition do not fully capture the essence of the popular interpretation, and the most common definition provided outside the scientist's arena -- most famously described by H.G. Wells when he compared movement through time with movement through space -- is notoriously defective due to the subconscious inclusion of other spatial assumptions, the problematic 'Myth of Passage' being a direct descendant of this form of temporal analysis (see Chapter 5). Among those studies which have been conducted within the sphere of philosophy, a rare example of an attempt at definition is provided by Paul Horwich in *Asymmetries in Time*, where he writes that

To travel in time is to traverse some temporal

interval in a time that differs from the duration of that interval.

Horwich, 1987, p. 114.

But even here the intent is not to classify the method of time travel to be analysed, but merely to supply a working description that may be used to determine whether or not the term 'time travel' is inherently contradictory. Murray MacBeath's *Who Was Dr Who's Father*, and Jonathan Harrison's *Time Travel for Beginners* and *Jocasta's Crime*, provide story-lines -- as opposed to specific definitions -- which are then analysed. This is a method common to the majority of philosophical discussions on the subject, and indeed, once a clear definition has been provided here, the remainder of this study will depend upon a similar system of thought-experiment followed by analysis.

Of all the articles written on time travel, the sections devoted to the subject in Chapter 10 of D. H. Mellor's book *Real Time* represent the fullest definition that I have encountered. It is typically comprehensive in its analysis¹, but his definition of forward time travel raises an interesting problem. He describes it as

not restricted as the flow of time is to a tautological rate of seven days a week. An example of it would be someone taking only ten minutes to reach the end

1. Although some, such as P.J. Riggs (1991), would not consider the argument either convincing or sufficiently thorough to fully explore the problems raised.

of the next century; and that is an objectively possible achievement...All we really need is a sufficient slowing down of processes of change and decay so that they take a century to reach the point they would otherwise have reached in ten minutes...

Mellor, 1981, p. 171.

He goes on to argue that both the results of Special Relativity and, for living organisms, freezing or other methods of slowing biological processes achieve the same end, and consequently

Rip Van Winkle was a time traveller...and so in its humble way is every hibernating animal.

Ibid., p. 172.

While few would feel satisfied with the claim that time travel into the future is employed by the hedgehog on an annual basis, it is difficult to define future-directed temporal relocation in such a way as to exclude such examples. The hedgehog's experience of the passage of time, both psychologically and with regard to its own bodily processes, is slowed down, as are the experiences of the time traveller relative to those not travelling with him. In the case of cryogenics, physical decay is halted, and a person successfully awakened from his or her deep freeze will experience a sense of temporal relocation as real as that of the time traveller in Wells' description. True, Wells'

traveller could experience events within the machine (the movement of the hands on his own wrist-watch, for example) that the sleeping or frozen traveller could not, but no one would claim that Wells' creation would be any less a time traveller if he were frozen before being put into his machine. The difference, and a possible distinction, is best revealed if one examines the 'twins paradox' and its resolution.

Einstein was concerned that, according to the claims of Special Relativity, one twin (call him Peter) leaving earth at high velocity and then returning would age considerably less than his brother (call him Paul) left behind on Earth. The problem is that if Peter's behaviour is relative, it would be just as correct to claim that Paul was moving away from him as *vice versa*, and consequently there should be no age difference. The missing factor was acceleration. One twin, but not the other, is accelerating relative to an inertial frame. Peter is, in effect, the active partner, accelerating away from, and then back towards, the planet, and so reaping the benefits. It can be imagined that, as Peter begins his journey, Paul is frozen, to be awakened by his brother upon the latter's return. In this way neither would have aged as much as the passage of time on the planet warranted (indeed, Paul will not have aged at all relative to any time frame), but whereas Paul preserved his youth by passively succumbing to the effects of drugs and low temperatures, Peter actively went about the task of speeding up the passage of time on Earth relative to him, whilst preserving the normal rate of

temporal passage within the time machine. His physical and psychological experience of temporal passage in his immediate vicinity is unaffected, and an atomic clock could measure the passage of that time even if the traveller were also frozen. Thus an active/passive distinction is indicated, the passive distinction verging on a 'Cambridge change'. It is not that the sleeper has time travelled, it is that the rest of the world has not slept with him. Time, in the frame of reference relative to which he is said to have travelled, has continued all around him, and he has been carried along with it, failing, because of his slowed state, to experience that passage. Conversely, even were the entire planet to be propelled into the future via some spectacular space-time anomaly, it would still be possible to state that time travel into the future had occurred, and even to determine how far relative to the moment of departure. Time, in the frame of reference relative to which the planet is said to have travelled, has continued, but not in the immediate vicinity of those travelling. Consequently they could age and experience events for a few years, only to return and find that millenia have passed in their original time frame². Yet the categorisation of 'sleepers' (such as the Seven Sleepers of Ephesus and Rip Van Winkle), cryogenically frozen biological beings, and hibernating animals as passive *time travellers* -- beings whose physical and psychological experience of the

2. Backward time travel is, by definition, active, due to the asymmetrical linear ordering of the time frame at rest with respect to the history of the planet.

passage of time in their immediate vicinity differs from that of others in the same area (a clock frozen with them would accurately represent the physical or psychological passage of time relative to any time frame for such travellers, i.e. zero) -- still retains a slightly unsatisfactory aspect. Furthermore, borderline examples may be imagined, such as the case where all behaviour, be it animal, vegetable, or mineral, in our solar system slowed to half speed simultaneously. Relative to our immediate surroundings time would appear to be passing normally, but relative to the universe outside our system we would appear to be moving very slowly, or the rest of the universe very fast. Is this an example of passive or of active time travel? The intuitive rejection of certain scenarios as examples of time travel is a psychological rather than philosophical or scientific problem, since the experience of those employing such systems, and their physical state after the 'journey', fulfil every requirement of time travel into the future; consequently further analysis is outside the purview of this study. To quote Mellor

Forward time travel is neither a problematic nor an especially remarkable phenomenon. It is really only an overly grand description of processes slowing down or stopping. Describing a stopped watch as having turned literally into a time machine does rather doll up the situation; and a repairer advertising cures for cases of forward time travel in watches and clocks would be

more derided than enriched -- as I shall be if I waste more ink on so trifling a topic.

Ibid., p. 172.

Henceforth all such systems will be regarded as time travel into the future, the imprecise (and, when analysed, totally unsatisfactory) application of an active/passive distinction providing a temporary salve to those who remain unconvinced. Time travel into the future, however it is achieved, is not a cause for philosophical investigation.

In contrast, Mellor's definition of backward time travel is far less derisory and considerably more complex. He begins with the suggestion that it would involve the reversal of processes -- an achievable task -- but this in itself is insufficient, since there are processes that can be reversed without time travel taking place. To show the differences between such processes and genuine time travel, Mellor gives the example of three clocks: (1) which runs normally; (2) which is time travelling into the past; (3) which has been fixed so that its hands always run in the reverse direction. The difference between the three, labelled C, C', and C'' respectively, is given by the following:

[1, C] e_1 precedes e_2 , affects it and is unaffected by it,

[2, C'] e'_1 succeeds e'_2 , affects it and is unaffected by it, and

[3, C''] e''_1 succeeds e''_2 , is affected by it

and does not affect it.

Ibid., p. 173.

C' represents the genuine backward time traveller's appearance to those not accompanying him (*per impossibile*, see Chapter 1) because, from the traveller's own point of view, events inside the time machine are not reversed but behave in the normal manner, with the cause -- such as water from a recently boiled kettle being poured onto leaves in a pot -- preceding the effect -- the manufacture of a hot pot of tea. Furthermore, with examples of genuine time travel it is not merely events within the time machine that appear reversed to an outside observer, but the ordering of events before he begins and after he finishes his journey. Hence, the switching on of the machine in 2000 AD precedes and is the cause of the arrival of that same machine in 1800 from the traveller's point of view, whilst the events in 1800 precede those of 2000 AD relative to an observer who is not time travelling.

Yet despite the force of his argument, Mellor's description is nevertheless unsuitable for this thesis, for from it he derives two logical consequences. One is that all time travel into the past necessitates the existence of closed loops (an hypothesis with which this thesis concurs; an argument in support of this claim will be presented in Chapter 5), and the other is that time travel into the past necessitates backward causation. This is not a contention to be supported in the following pages and, again, full analysis

may be found in Chapter 5. What, then, is the definition of time travel with which this thesis will be concerned?

In simple terms the following pages will be dedicated to proving whether or not it is logically possible for something to carry (or transmit) information into the past relative to the moment of departure; or, to put it another way, whether we can or will ever receive a message of any kind from the future (time travel into the future having been shown to be considerably less problematic and, in a very real sense, possible). But if time travel into the past is defined as the temporal relocation of information to a period lying in the causal past relative to the moment of departure, there remains the problem of the ambiguous use of the term 'information'.

The Collins Dictionary and Thesaurus defines information as

1. Knowledge acquired through experience or study. 2. knowledge of specific and timely events or situations; news. 3. the act of informing or the condition of being informed.

Collins Dictionary and Thesaurus, 1986.

The combination of definitions 1 and 2 in particular seems to sum up neatly the commonest examples of a time traveller's characteristics, but this also introduces the concept of knowledge -- a concept that is hardly devoid of problems within the boundaries of philosophical debate. As such, it is of limited value at this stage. It is the nature of the

information that is to be carried which can provide a greater insight into the system of time travel to be investigated.

If this examination is to be concerned with whether or not information may be transmitted or carried into the causal past, then the prime concern must be to determine whether the system employed enables the communication of the temporal origin of the transmission or journey, for it is a fact that only time travelling objects which come from the future relative to the moment of arrival generate problems. In order to communicate futuristic temporal origins, the system must exhibit two features: (1) it must be capable of causal interaction; (2) anything possessed by the system at point C - - C being posterior to A, relative to a time frame at rest with respect to the history of the planet (see Chapter 2) -- is preserved during its travels backwards to point A (see above). Hence, if a time machine is scratched at point B, that being a position between A and C, that scratch is still exhibited upon the machine's arrival at A. But marks or physical organisation are not the only methods by which the results of events in the future may be carried into the past relative to the moment of departure. The existence of an object may be sufficient if, in advance, it is determined that matter is to be sent from the future to a particular spatio-temporal location. The detection of energy or matter at the specified space-time under regulated experimental conditions could generate a bilking experiment, and so must be included as a method of communicating information about the future and

hence the temporal origins of the message. This does, however, require that a positive temporal and causal direction be preserved for the information, even when it is travelling backwards in time. The applications and implications of this caveat are more fully explored in Chapter 2.

From the above, the definition of time travel to be examined in this thesis is revealed; for if the person or object is not capable of causal interaction, he/it is incapable of communicating with or affecting objects or persons within the time in which he/it exists. Consequently he/it would not breathe, or be seen, or displace molecules in the past relative to the moment of his/its departure, and so there would be no proof of his/its physical existence at that time. An example may clarify the issue still further. A person with a powerful telescope situated upon a far distant planet might point it at the Earth and see dinosaurs walking the surface -- and this is not problematic, as shown by our freedom to admire the night sky -- but such an action is not considered time travel according to the above criteria, since the observer on a distant planet is not interacting with the Earth in the Cretaceous period but merely observing reflected light given off at that time. Only if a response from that observer precipitates causal interaction prior to the emission of those photons could bilking experiments be generated, and under such circumstances time travel would be said to have taken place.

Mention has been made of interaction within the causal

past, and a physicist might well re-interpret this as meaning interaction within the light cone that lies in the past relative to the moment of departure. But this is simply because the light cone presently defines the fastest system by which messages may be dispatched and received. However, were another method discovered by which the speed of causal interaction might exceed that of light, then the cone which represents the optimum reaches of causal interaction under that description would define the boundaries of backward time travel for this study. Thus interaction within the causal cone lying in the negative direction relative to the point of departure would represent backward time travel, since any action performed within those boundaries would be in a position to propagate consequences that could affect events at the point of departure and so at the point of origin of the event. Were a time traveller to journey to a spatio-temporal location that did not permit the arrival of any causal consequences of his actions until after the moment of his departure, this would not be considered an example of time travel into the past as popularly conceived, even though it could be an instance of time travel into the relative past as designated by Einstein's Special Relativity Theory. This is because the popular system includes the implicit assumption that the traveller into the past is in a position to affect his own existence or that of others around him before the moment of his departure.

What of the second criterion raised above? What is the

importance of preserving what may be termed the causal history of the information being transmitted into the past? Causal history includes memories, marks, physical location, and organisation. In order that the temporal origins of an object may be determined it is necessary that, at the very least, one of these elements is preserved as it journeys into the past. For if the causal history is in some manner negated as travel into the past occurs, there remains no indicator of temporal origins, and so no proof that time travel from the future relative to the moment of arrival has taken place (see Chapters 2, 3 and 5).

Time travel into the past as defined for this thesis is therefore the temporal relocation of information, by any method, into the causal past relative to the moment of departure; and information is defined as consisting of, at the barest minimum, a means of verifying the future temporal origins of that information. These may, in turn, be communicated by its organisational structure or spatio-temporal location. The method of conveyance is limited only by its capacity to preserve the causal history that provides a means of determining the temporal origins of the object said to be time travelling, and its ability to convey an object or person in such a manner that the power to interact in the past -- a feature required if time travel is to be detectable -- is also preserved.

Section 2

Why?

As time travel is typically associated with scientific, rather than philosophical, research, and more often than not considered suitable only for science fiction, I will now provide an explanation for my choice of subject.

1. Human Freedom. Despite man's astonishing technological advances over the past one hundred years or so, there is one shackle of which he cannot divest himself: he is incapable of escaping the passage of years. He cannot correct the mistakes of the past upon the realisation of present unpleasantness, nor can he go into the past to verify events or decide issues. Regardless of his academic or financial standing, no man can ever affect what has been, and yet his future life will, to a lesser or greater extent, be affected by it. A man paralysed in a driving accident will never live again as he once did; a student who fails an important exam finds a door slammed shut which may never open again; a mere slip of the tongue may be a cause of constant regret throughout a lifetime. In each case the individual concerned may wish it were possible to correct the error, but at present both scientists and philosophers -- while still keeping their options open -- are at best sceptical and at worst derisory regarding the potential for backward time travel, particularly if that potential includes the freedom to change or in some way affect the past.

Consequently those who would be time travellers concede the arguments propounded and 'make the best of a bad job'. Yet many of the arguments so far suggested do not, in themselves, completely dismiss the possibility of time travel. Were it possible to describe a logically coherent system that showed this activity to be more than a science fiction writer's dream, perhaps some (I do not say all, as many are inherently contradictory -- as this thesis will show) of the aforementioned limitations upon man's freedom would be removed.

2. Popular Science Fiction. Since the publication in 1895 of H.G. Wells' *The Time Machine*, an enormous number of books and -- in more recent years -- films have appeared that consider the possibility and implications of backward time travel. This is not to claim that no one had ever considered the subject before. The image of time as 'the ever flowing stream' upon which we float, helpless to correct past errors, has been explored since at least the time of the pre-Socratics (witness Heraclitus: 'Panta rei kai ouden menai' -- 'Everything flows, nothing remains', a rueful comment on the inexorable passage of time). However, in the last century the combination of space travel and (I suspect) cinematic effects has made time travel, if not actually physically possible in the manner popularly conceived, then at least a less fantastic prospect and more accessible to the imagination. Thus books, articles, and films employing time travel include (among many others too

numerous to mention) Robert A. Heinlein's *All You Zombies* and *By His Bootstraps*, Ray Bradbury's *A Sound of Thunder*, Anne McCaffrey's *Pern* series, Douglas Adam's *Dirk Gently's Holistic Detective Agency*, Jack Finney's *Time and Again*, and an amusing article in Larry Niven's *All the Myriad Ways*; also Steven Spielberg's *Back to the Future I, II and III*, Disney's *Flight of the Navigator*, *The Terminator* (I and II), *Star Trek*, BBC T.V.'s *Dr Who* (although despite the basic plot device this programme rarely deals with the problems of time travel as defined) and the American series *Quantum Leap*. As can be seen from this list, the film industry has recently turned to time travel as a new and lucrative subject for exploitation. Unfortunately, very little thought has been put into many of these works, and few withstand more than a cursory glance before even the least well informed espies contradictions.

3. Science Fact. The mention of time travel to a physicist is not guaranteed to evoke a derisory response. Richard Gott at Princeton University has recently suggested cosmic strings as a possible means to backward time travel, leading Stephen Hawking at Cambridge to add fuel to the debate with his 'Chronology Protection Conjecture'. David Deutsch at Oxford has defended the possibility of time travel, with certain caveats, and the whole re-awakening of interest in the subject has led to the appearance of a number of television and newspaper articles which, whilst often imprecise due to the intensely erudite nature of the scientific articles with which

the reporters are grappling³, do reflect the sudden increase in interest within the scientific community. In addition to the macroscopic concepts of worm-holes and infinitely long cosmic strings that warp space-time, interpretations of particle behaviour that refer to travel at speeds faster than light, and hence time travel, do exist and there is, at present, no clear indication that these interpretations are incorrect. However, the implications were time travel possible have already caused consternation (see Benford, Book and Newcomb's *The Tachyonic Anti-Telephone*), and such studies should come under philosophy's wing.

4. Philosophical Interest. This, sadly, has not been great. There are some notable articles that have been written on the subject, and many of them will be referred to during the course of this thesis. However, some are more notable for their marked pre-judgement of the issue than for fair philosophical argument. For example, Anthony Flew, in his article *Time Travel and the Paranormal*, says that we should recognise

*the at least prima facie incoherence of all
talk about time travel.*

Flew, 1988, p. 267.

and adds later that

3. One reporter from a national newspaper, whom I contacted with regard to an article on time travel that he had written, admitted that he had not actually read the papers to which he had referred but was merely reciting commentaries written by others.

quite apart from all the contradictions involved in such experiences as those of being a witness in 1987 to a battle which occurred in 1066 or of being directly affected by the happening of things which have not yet happened, the time traveller would have to be not a flesh and blood person but a disembodied soul. And it is not to be taken for granted that that suggestion is any more coherent than the others.

Ibid., p. 268.

Unfortunately, such surface skimming is typical, and has given the subject a worse reputation than it already possessed. To add insult to injury, many philosophers seem to consider time travel only when they desire a 'mental holiday' from the rigours of so called 'serious' intellectual thought. Jonathan Harrison's *Dr Who and the Philosophers or Time Travel for Beginners* and *Jocasta's Crime* both appear to fit this category, as does Murray MacBeath's *Who Was Dr Who's Father?*. I am sure both would claim that there was, in point of fact, a serious intent behind these articles, which raises the problem that time travel simply is not taken seriously. Part of the reason lies in the necessary use of colourful thought experiments, and part in the association with commercial successes (poorly thought out from a philosophical perspective) such as *Dr Who* which is not only hard to shake off, but is positively encouraged (witness the titles mentioned above). A justification of the methods employed

throughout this thesis will appear later in this introduction; here I will only state my belief that philosophy need not be boring in order to be relevant, and when a subject is as difficult as time travel any method that makes it available to a wider audience is to be encouraged, provided it does not detract from the power of the argument or cause the reader to ignore the reasoning in favour of the story-teller.

5. Personal Interest. As this is vital to the successful completion of any thesis, I chose a subject whose ramifications have long been of interest to me. Curiously enough I did not like science fiction books on the whole, although some of those I encountered in the course of writing this thesis did cause me to reconsider my opinions on the quality of the genre in general. I have, however, decided to concentrate my energies upon philosophy and science for background, and philosophy alone for argument, in an effort to minimise any antagonistic response resulting purely from the commercial as opposed to academic origins of the examples. My use of science fiction or fantasy as an aid to understanding during the course of what follows, therefore, must now be explained.

Section 3

Justification of Method

Throughout this thesis considerable use will be made of thought experiments. These have a long and distinguished

heritage ranging from Zeno's Achilles and the tortoise and Plato's Cave, to Boethius' cartwheel, Hume's billiard table, and finally, in the 20th century, myriad thought experiments which, while not so famous at the moment, will in some cases doubtless become so in due course. Some philosophers are more renowned than others for employing this method. Dummett, Lewis, Putnam, and Einstein have all applied thought experiments regularly and to great effect, and will be considered, together with many others, in due course. However, the use of thought experiments is not always viewed so benignly. K. Wilkes, in her book *Real People, Personal Identity Without Thought Experiments*, gives over a long and interesting first chapter to their uses and dangers. Her arguments must be considered, as the value of my conclusions must necessarily rest upon the validity of the method of their extraction.

Philosophers are not the only members of the academic community who employ thought experiments. Scientists too have been known to use the words 'Suppose the following were the case. What would happen then?'. Einstein, who more than any other earned the title philosopher-scientist, considered what one would see if one were to travel upon a beam of light, and the consequences of his *Gedanken-experiment* are the basis of the presently accepted scientific view of the universe as a relative, rather than absolute, system. Naturally, the world of science did not simply accept Einstein's claims without empirical evidence: experiments were designed to test his

theories, and after they were found to be correct they were built upon and further hypotheses extrapolated from them. However, the thought experiment itself was justified, despite the fact that it could never occur. This was because the inability of the human frame to withstand the pressures exerted upon it when it is accelerated to the speed of light is irrelevant to the experiment, which was concerned with the behaviour of light itself. Thus Wilkes concedes the validity and necessity of this sort of thought experiment. What then of the philosopher's fantasy life?

According to Wilkes

philosophical thought experiments are, in theory at least, intended to tell us what we would say if..., precisely in the world as we know it from our scientific theories -- so that we can explore the ramifications of the concept in question.

Wilkes, 1988, p. 46.

Personal identity and time travel both share an enormous burden of thought experiments. Suppose one were to awake with all the memories of Socrates or Charles I; suppose one were to step into a machine, flick a lever, and find oneself facing the Ironsides at Marston Moor, and were informed by the combatants that the date was July 1644, what then? According to Wilkes the answer depends all too much on the information you may have left out. If one cites actual examples, all necessary information is contained within them simply because

they occurred. Thus

basing our arguments on actual cases allows us to check our imagination against the facts, and our intuitions get strengthened and rendered more trustworthy.

Ibid., p. 48.

However, when one creates a thought experiment, one is necessarily forced to specify, rather than assume, the required details, and it is all too easy to omit those which are either too obvious or too obtuse. How can one guarantee that one does not make errors that could affect or negate the conclusions drawn from the example? Wilkes argues that this guarantee is required, since without it all one can say is that in our ignorance

we do not know whether the state of affairs is theoretically possible or not; and that is a long way from saying that it is possible.

Ibid., p. 31.

Secondly, many thought experiments assume situations which, according to Wilkes, could never obtain in this world; hence their validity is once again tainted. For example, she queries the value of asking what would follow were a human being to fuse with another or split into two like an amoeba, when the event simply cannot occur? Where is the dividing line between these suggestions and pure fiction? Wilkes comments

that

[T]hought experiments are, like all experiments, undertaken for a specific purpose. [In the amoeba case] everything else is going to be so unimaginably different that we do not know what concepts would remain 'fixed', part of the background; we have not filled out the relevant details of this 'possible world', except that we know that it cannot be much like ours. But if we cannot know that, then we cannot assess, or derive conclusions from, the thought experiment.

Ibid., p. 12.

From the above it would appear that thought experiments are a minefield whose potential for self-destruction seems to make their avoidance the primary concern of cautious researchers.

The arguments raised by Wilkes are indeed powerful, and I have by no means covered every attack she makes, merely the more salient points. However, whereas personal identity and time travel share the superfluity of thought experiments, they are very different in one important respect: whereas one can take examples from life to discuss identity, the same does not hold true of time travel into the past. Indeed, the aim of this thesis is to determine whether or not time travel of the form described above is possible. To refuse to use thought experiments under these circumstances is to refuse to discuss the subject altogether, and that is a recipe for stagnation.

. One might ask why I do not concentrate upon scientific

experiments; after all, to quote Sklar:

[t]o try and carry out a philosophical discussion about such a problem as the nature of space and time without relying upon the results of physical theorizing is to walk blindfold when one is equipped with extraordinarily useful eyes.

Sklar, 1974, p. 417

My reasons for not doing so are: (1) As a philosopher and not a scientist I lack the scientific background to perform the task adequately; (2) as revealed in the definition of time travel provided at the beginning of this chapter, the characteristics of the popular concept are not always catered for within the scientific arena, and it is the logical possibility of the popular understanding of time travel that I wish to investigate; (3) the most promising area of study at present appears to lie in the region of quantum physics, which in turn is proving incredibly alien to our understanding of the macroscopic world that we inhabit, and until a means is discovered of uniting quantum theory with gravitational theory, this situation will doubtless continue. Since human beings and other macroscopic objects do not behave in the same way as photons, and since our existence in any particular state is not generally understood to be dependent upon the observations of others, there is little value in my utilising studies which are not (at present) applicable to the definition of time travel under consideration. Consequently,

while mention will be made of appropriate scientific references, their use is limited by the nature of the area to be explored, and I am therefore forced, if I am to discuss the subject at all, to make some appeal to thought experiments of my own devising.

The value of thought experimentation lies not only in their use when discussing what has yet to be achieved, but also in their power to push any given theory to its extreme. I cannot design a time machine, but I can subject carefully chosen hypotheses to tests of coherence. Should I find that time travel, as defined earlier in this chapter, necessarily involves contradictions then, provided the validity of my method is accepted, I will have shown it to be logically impossible and therefore physically impossible.

What would be a valid test of my methods? According to Wilkes

we should look rather to the 'theoretical', or 'in principle' possibility of the relevant background conditions -- the conditions we need to specify before we can be sure that both the imagined scenario is adequately described, and that the inference from the imagined state of affairs to the conclusion can be made.

Wilkes, 1988, p. 18.

These background conditions have already been stated in the definition. In addition, no consideration is to be given to the study of time travel by disembodied spirits as suggested

by Flew (above). This is due to the considerable difficulties that arise whenever any attempt is made to explain the nature of a disembodied existence. Problems typically raised include queries as to the site of memory storage, how it could see, hear, touch, smell or taste without the necessary organs or a brain in which to analyse the information, and how it can be said to have a position when there is no physical substance with which any other given object can hold a spatial relation. A further issue worthy of consideration concerns the logical argument being invoked: why should a time traveller need to be disembodied? In fact an appropriate answer to this, although not specifically addressed to the problem of disembodied spirits, appears in Chapter 5. In this thesis I am not concerned with one particular method, but with time travel (as defined) *per se*, however it may be achieved, although as the argument proceeds certain methods may present themselves as more logically coherent than others. An argument could be presented for querying the validity of a study of the logical problems associated with a physically impossible phenomenon, but it has yet to be proved conclusively that time travel lies in this category, as indicated by the aforementioned resurgence in scientific interest.

Some consideration should now be given to the nature of the time machine itself. For those who have seen the film version of *The Time Machine* a particular image will probably spring to mind: that of a machine with a large rotating wheel upon the back, plush red velvet upholstery, a lever with a

crystal base, and brass fittings. Whilst perhaps aesthetically pleasing, such a description is hardly practicable since a time machine must be capable of propelling itself through space as well as time. This is due to the fact that our planet circles the Sun; these two, together with the remainder of our solar system, orbit the galactic centre, and the galaxy itself is moving through space. Should the machine only be capable of movement through time, a traveller into the past could not alter his temporal location and maintain his spatial position relative to the planet. Consequently the machine must be capable of self-propulsion, and since high velocities will be required to cover the intervening spatial difference between the planet's present and earlier positions there must also be a means for the protection of the traveller. Present space-ship technology indicates the possibility in principle of a machine capable of high velocity movement through the vacuum, and so the utilisation of such a machine may be assumed as a working hypothesis. Since the aim of this thesis is to determine whether a machine capable of travelling backwards through time is logically viable, this physical description lies within the parameters laid down above for thought experiments. Should the results in any way hinge upon the physical structure or behaviour of the time machine -- rather than that of its occupants, or the fact that it is travelling backwards through time and not just in a linear fashion through space -- this description will be replaced with one more appropriate to the conditions (as in Chapter 3, Section

3, and Chapter 5). Since the aim of this thesis is to determine whether time travel as defined above is possible, and that definition does not cite any particular method of temporal relocation, it is important that the method used at any given point in the discussion does not restrict the conclusions drawn.

How will the time machine achieve its design aim? Whilst this question is understandable, it is not actually relevant to the discussion in hand. As suggested earlier, it might prove possible to make use of worm holes in space or other gravitational anomalies, and by the end of the next century we may have discovered alternative methods. However, if the conclusion of this thesis should be that backward time travel is logically impossible due to fundamental contradictions, inherent in the process, that cannot be resolved, rather than as a result of the methods employed or the persons/objects involved, then whatever discoveries are made they will not enable its existence, for logical possibility is a necessary precursor of physical viability.

This introduction has highlighted the inappropriate nature of Wilkes' test to this thesis. This is due to the necessity of a suspension of disbelief for the purposes of initiating investigation into the subject. But under such circumstances how can one avoid falling into the trap of proving that from the impossible anything follows? First by remembering the fact that time travel, as has already been stated, has not been proved impossible -- to establish whether

or not that is the case is the purpose of this thesis. Second, by subjecting every argument to tests of logical consistency and coherence -- not just internally, but within the entire universe in which this activity is to be pursued. Whilst I cannot guarantee to cover every detail -- that is the limitation of thought experiments -- it is possible to subject any hypothesis to considerable logical pressure, attacking every premise with equal force until one gives way -- and in this lies their advantage.

So far I have defined the subject area, outlined my intentions, and justified the use of thought experiments, but what of my use of science fiction and fantasy? How can this be justified? It should be remembered that the first notable fiction work on the subject was by H.G. Wells in 1895. There was another previous to that, by F. Anstey in 1891, called *The Time Bargain* or *Tourmalin's Time Cheques*, which pondered the possibility of causality violation -- a subject that the scientifically trained Wells neglected to consider -- but this book was overshadowed by its contemporary's success and few have heard of it. Since then, many writers have given intelligent consideration to the subject, and it would therefore seem short-sighted and unnecessarily insular not even to pay lip service to what has been written, even though reasons of copyright as well as the need to include only those aspects of the story that are relevant will result in a total dependence upon self-created thought experiments for analysis. All references to well known science fiction made in this

thesis will therefore be expansions, provided either as a supplement to the descriptions already given, as an aid to visualisation, or as additions to point the way to how others have dealt with the problem. I cannot claim originality in the ideas to be tested, or even in the means of testing them, but in the conclusions reached and the unification under one title of a great many opinions upon the subject of time travel, originality does, ultimately, reside.

The next chapter will mark the beginning of my investigation within the parameters outlined above. It will contain an initial description of an incident of time travel as presently defined, followed by an analysis in which the various elements will be highlighted. Where feasible, these elements will be subjected to immediate investigation; otherwise, direction will be provided to those specific chapters in which an in-depth study of the problem, and its possible solutions, may be found.

Chapter 1

Section 1

A General View

This chapter is intended as a general introduction to the particular problems, generated by time travel into the past as defined, which will be encountered throughout the course of this thesis. It is hoped that any remaining confusion regarding the nature of the system under investigation will be resolved through consideration of the following thought experiment and its subsequent analysis. In order that all the aspects to be analysed in the following pages be raised, a human time traveller using a time machine has been used as a blueprint for discussion. In this way problems concerned with human freewill and the physical nature of the time machine may be raised along with those of interaction, temporal anomalies, and causality violation that apply to all methods of time travel.

Imagine, therefore, the time traveller preparing for his first journey into the past. Certain precautions can be assumed to have been taken in advance for the purposes of survival, such as the administering of inoculations against diseases which, though long since eradicated, were prevalent in the years to be visited, but there are other precautions that must also be taken into consideration, whose nature and purpose are best summed up in the following quotation from Monte Cook.

The real reason for time travellers to take certain kinds of precautions is not for them to avoid changing the past; [it]...is for them to play the odds.

If you want to visit Socrates' trial, don't dress in twentieth-century clothes -- the odds against someone's having been present at Socrates' trial dressed in twentieth-century clothes are astronomical. If you want to visit Socrates' trial, dress appropriately, speak the language, know the customs and so forth. In this way you'll be playing the best odds for your having been present at the trial.

Of course, if the records of the time you want to visit tell of a bizarrely dressed, strange-tongued, odd acting visitor, you need to take that into account. (If your visit to the past can explain something hitherto inexplicable, so much the better.)

Cook, 1982, p. 54.

Consequently our time traveller (who will henceforth be termed Chronos for the sake of brevity) must be both informed and protected to ensure the maximum chances of survival and success.

Assuming all appropriate precautions have been taken into consideration, it would be reasonable to suppose that the would-be time traveller would incorporate a test into his first venture by which he might determine whether or not he is successful. To this end it may be imagined that Chronos takes

with him an object which can be left behind in the past. It should be of a substance that will not degenerate and that can be easily hidden, in order to maximise its chances of survival. Here one might ask why Chronos does not simply leave a mark, whilst in the past, that can be easily detected at an appropriate future date. The reason is, as above, because he must 'play the odds'. No scientifically verifiable evidence has ever been found to indicate the previous existence of a time traveller, therefore any sign left by such a person must be both well hidden and easily and unquestionably recognisable for what it is. A rock that has been painted or otherwise marked by what appears to be an intelligent hand is not acceptable, even if it contains a signature, matching that of the time traveller, that can be tested by means of carbon dating, for this could still be coincidental (albeit in the face of overwhelming odds). However, the discovery of a plastic sheet containing both an autographed hologram of Chronos and information on 20th-century technological advances would, I believe, be considered more than acceptable evidence if it were, for instance, located in the very fabric of an ancient monument. Thus, if such an object -- recently known to have been involved in time travelling experimentation -- were uncovered during repair work on the pyramid of Cheops, in a position that could only be accounted for if it had been inserted during the original construction of the tomb, and if scientific examination revealed no more recent damage or alteration to the tomb's structure, and there was no other

explanation for its existence in that position, then this could be considered proof of the activities of a time traveller at a much earlier moment in the history of the monument.

Imagine Chronos inoculated, appropriately garbed and informed, and armed with the potential proof of his activities, stepping into his machine, pressing the relevant buttons to programme the intended date of arrival, and stepping out again in Egypt, on the plateau of Giza, in the inundation of the year 2588 BC. If his journey is successful he will then be in a position to watch the construction of the pyramid of Cheops, and having established beyond question his temporal and spatial position (perhaps by means of the stars), he could conceal the hologram in the base of the pyramid, including with it some beacon by means of which it could be detected by modern techniques so as to enable its future discovery.

Still further aspects may now be added to the thought experiment without excessive complication. Imagine that Chronos pauses in that space-time position until it is no longer physically possible to remove the hologram without the reconstruction of a vast section of the pyramid, and thereby he ensures his proof remains in position. During this interval, Chronos is approached by someone who establishes himself as Chronos' older self. This person (Chronos-old) discusses events that will occur after Chronos-young's return from his trip, after which the latter bids his older self

goodbye and steps back into the machine. Chronos-young moves slowly forwards through time in order to follow the building of the pyramid through the windows of his machine, and, when he is finally satisfied that the hologram is safely embedded, returns to his own time (i.e., the year of his initial departure).

Having re-established his temporal position, Chronos pinpoints the location of the hologram inside the pyramid with the sensing equipment. It is removed (with some difficulty) and found to be exactly the piece of modern design described above, positioned in such a way as to defy attempts to place it today without very severe and easily detectable damage to the pyramid¹.

Section 2

An Analysis of the Problems Highlighted by the Experiment

With the completion of the initial description comes the need to distinguish those problems contained within it that will constitute the substance of the following chapters, as well as those which, while problematic enough to warrant explanation, are of insufficient magnitude to be granted chapters of their own. The latter will be analysed within this section.

(I) The first problem encountered -- termed 'playing the odds' by Monte Cook -- will be discussed in the chapter

1. The fact that its removal would also cause irrevocable damage to the pyramid is a matter for aesthetic, not logical, concern.

entitled *Freewill and Determinism*. It is concerned in part with the consequences should a person attempt an act in the past of sufficient worth to guarantee a report, but for which no such report exists: for example, a traveller visiting the Battle of Waterloo with a large number of modern machine guns and tanks, despite the fact that no record exists of such weaponry at that event. It is also concerned with the implications for the individual's freedom not to act when an event occurs involving a future stage of the traveller to the stage presently occupying that space-time in the normal manner: for example, the traveller watches his future self commit a crime and, having witnessed the consequences of that act, decides not to perform it under any circumstances. He then proceeds to do everything in his power to ensure he is not present at that particular time and place when the crime is committed, even to the extent of attempting self-destruction in order to forestall the event.

In each case the immediate conclusion would be that he will not succeed. In the first case, this is because activities of such magnitude do not go unrecorded, and consequently there ought to be some register of it in history books or accounts preserved from that time period. As there is not, the simplest explanation is that he *will not* succeed because he *did not*. Similarly, in the second, there is evidence -- in the shape of past experience -- to indicate that the act will be performed at a later moment in the traveller's personal history. Hence from the fact that this is

what he *did do* there follow apparently inescapable conclusions regarding what he *will do*.

(II) In the above paragraph I highlighted certain temporal phrases -- 'did do', 'will do' -- and this leads directly into the next aspect to be considered, which I will term the problem of 'alternative temporal references'. In the initial description I spoke of the time traveller stepping into his machine, and a few moments later stepping out again to find himself in Ancient Egypt. The impression was thereby given that he had travelled more than four thousand, five hundred years in a few minutes. This, surely, is a contradiction, and some philosophers have dismissed time travel as incoherent upon this stumbling block alone (see Flew, 1988; Williams, 1968; Holt, 1981). Since this is an oft-cited paradox of time travel the chapter immediately following this one, entitled *Personal and External Time*, will be devoted to its dissolution by means of the introduction of carefully defined temporal reference points.

(III) So far the problems highlighted have all been contained exclusively within the bounds of logic and metaphysics. Yet some of the difficulties encountered in a thought experiment concerning time travel straddle the boundary between physics and philosophy, and in so far as they fall within the parameters of a philosophical analysis should be examined. Thus, I described Chronos as stepping into the

machine, pressing some buttons, and going backwards in time. In these circumstances is there not a danger of collision between the time machine moving forwards through time under normal conditions, and that same machine moving backwards relative to the temporal axis whilst occupying the same spatial coordinates as its earlier self?

The potential for clashes arising from an attempt to travel backwards through time is considered by Michael Dummett in his article *Causal Loops* (1986). There he examines and expands the descriptions at the beginning of Wells' *The Time Machine*. The reader is asked to imagine a time traveller who arrives from the year 2085 AD, this being a moment in the future relative to the temporal siting of the thought experiment. Dummett argues that two versions (he calls them 'exemplars') of the machine must appear side by side: one travelling backwards in time from our point of view, containing within it a time traveller whose bodily processes seem to us to be reversed, the other machine, from which the traveller steps, behaving perfectly normally provided no one tampers with it. This latter version is moved to a museum in order that it may be preserved. Dummett makes the hypothesis that the time traveller is born in 2045, but dies in 2020, and that consequently, after a pause between the years 2020 and 2045, there are two travellers existent on the planet. Furthermore, there will be at first two time machines, and later three. The explanation is as follows: one traveller will be in the time machine travelling backwards in time; the other

will be that same traveller earlier in his history, growing up, building the time machine, and finally stepping into it. Of the time machines themselves, one will be travelling backwards in time with the traveller; one will be the same machine later in its history after the traveller stepped out of it and left it in the museum; and the third will be the same machine at the beginning of its existence, as the traveller first builds it and prepares to use it. It is at this point that Dummett raises the matter at issue.

Note that he [the time traveller] cannot leave it [the time machine] standing for any length of time and then climb in and switch it on, since it would then have been in the way of itself. He has, rather, to set its controls, have it hoisted above the correct position -- which is occupied by that one of its other two exemplars that is not in the museum, but contains himself living backwards -- climb in, give the signal for it to be dropped and simultaneously press the 'On' button: he and it will then coalesce with their other exemplars and vanish, leaving only the surviving machine in the museum.

Dummett, 1986, p. 139.

A visualisation of Dummett's thought experiment, together with a clearer explanation of its implications, can be provided by means of graphic illustrations. Fig. 1.1 illustrates the time machine's life history as described above. Figs. 1.2 and 1.3 depict the problem Dummett is trying

to prevent. In the former, the time machine has been left in one position for some time before being activated. In the latter, there is only a brief but nevertheless sufficient period of time during which the machine occupies the same position travelling forwards in time that it will occupy when travelling backwards. Both would seem to be recipes for disaster, since in each case it appears that two objects are being asked to occupy the same physical space during the same temporal period. However, there are some fundamental errors in Dummett's reasoning.

First, as mentioned earlier (see Introduction, Section 3), were one to travel backwards in time it would also be necessary to travel in space. Without some form of propulsion capable of equalling the speed of the Earth's movement through space (measured at just under 19 miles per second), how can a guarantee be given regarding the time machine's capacity to remain static relative to the surface of the planet when only the time machine is travelling backwards? The image of the machine remaining in the same physical space whilst the rest of the world appears to be moving backwards relative to it is persistent, but is not supported by common sense. This argues that the machine would, upon initiating a backward journey without physical propulsion, be left floating in space since it would be occupying a position which the Earth, at that moment in time, has yet to attain. Consequently it would appear that in order to travel backwards in time, arriving at the intended temporal and spatial position, it is also

necessary to travel through space. However, the need for physical travel is not merely a matter of convenience: the logic of relativistic theory would seem to demand it, and it has proved impossible to separate space and time whilst preserving any true understanding of either in isolation. But if the time machine must necessarily be capable of physical movement by means of its own engines, there would appear to be no reason, at this stage, to demand that it only occupy those positions it occupied on Earth before its backward journey began, and so the collision envisaged by Dummett between a time machine travelling forwards and then travelling backwards *in the same space* can never be realised in that form. Chronos can choose wherever he will be spatially whilst travelling temporally, and the only demand is that he be in the correct region of space for the moment of his arrival upon Earth. However, whilst Dummett's image of disaster is not strictly accurate, some consideration must be given to the fact that, whereas the planet does move, its speed relative to any point is not such that it could remove the possibility of any collision between travelling and non-travelling time machines. Since even the slightest connection between one part of the time machine moving backwards through time and another existing in the normal manner would be sufficient to cause a crash at least, some method must be determined which can prevent this ignominious end to the traveller's intentions. Both instantaneous spatial movement at the moment backward time travel is initiated and movement through space-time such

that direct reversal of the local temporal direction is never experienced (as in the Gödelian model or worm-holes) resolve the problem, and since any method is acceptable provided it coheres with the definition above, and both these suggestions do, either may be used as a working alternative to the possibility of crashing machines.

There are other problems with Dummett's system. He asks the reader to imagine the time traveller coalescing with his other self who is travelling backwards in time, and he cites elaborate procedures to ensure that the time machine is correctly positioned (such as the crane and the moment at which the time circuits must be engaged) in order to forestall an explosive union between the two at an inappropriate moment. The impression is thereby given that this can in some way influence the efficacy of the machine, yet once again the problems envisaged are illusory.

The argument necessitates a re-interpretation of the causal order. For in placing the machine according to the position of its later self travelling backwards through time, Dummett makes the effect -- the already existent, backward-travelling machine -- into the cause -- the positioning of that machine before it begins its backward temporal movement. Yet it must be recalled that the physical location of the machine travelling backwards, at time t_{-1} , is a result of the behaviour of the time traveller at a moment in the future (t_{+1}) before (in the traveller's own experience) he began his journey (t_0). Furthermore, to position the machine according

to where it *will be* is not only to reverse the normal direction of cause and effect -- an attack regularly levelled against time travel, and which will be considered in due course (see Chapter 5) -- but also to deny the occupant of the machine any freedom of will (see Chapter 4).

On a final note, Dummett's use of the word 'coalesce' is potentially misleading. It suggests two or more distinct entities combining into one. In fact it is not that the machine at space-time position t will merge with *another* machine at position t_{-1} , but that the machine at t , at a later moment in its personal history, is the machine at point t_{-1} . Thus it is not so much a coalescence as an ordered passage of causally connected stages in the life history of one object. A distinction must be drawn between the temporal direction experienced by observers who are not time travelling and the way the machine *appears* to behave, and *its* temporal direction and the way it *does* behave. The associated problems of freewill, identity, and personal and external time references will be dealt with in more detail in the appropriate chapters.

(IV) The next difficulty encountered is one strongly linked with the problem of freewill, and has already been mentioned: it concerns the direction of cause and effect. There are three inter-connected difficulties that arise under this heading -- backward causation, closed causal chains/loops, and causal contradiction. Some clarification of their position in discussions of time travel will now be

provided by means of examples. By placing the hologram created in the 20th century in the time machine and thence into the pyramid, Chronos is causing there *to have been* a hologram in the Pyramid from the moment of the latter's construction -- this would be an example of backward causation. On the other hand, were Chronos to travel back in time, marry a woman by whom he had children, and one of the children proved to be Chronos' own great-grandfather, this would be an example of a closed causal loop/chain, since Chronos' particular state of physical existence -- not just the mere fact of it, but the details which go to distinguish it from other human beings and mark it as a descendant of particular individuals -- is dependent upon the consequences of his backward temporal journey culminating in the procreation of his great-grandfather. (This also entails considerations of identity, and emphasises further the highly interconnected nature of the problems under discussion.) Finally, there is the problem of causal contradiction. This manifests itself when the performance of act *n* in the past actually negates the occurrence -- by direct causal influence or by causally connected intermediary stages -- of the event in the future that was the immediate causal antecedent of *n*. Thus *n*, by the fact of its existence, negates that existence. For example, Chronos might decide to test his machine by burying an article in a particular place in his garden, at a moment in the past, by means of his time machine. If his journey is successful, the article will be buried in the ground in the appropriate

position *before* he leaves, since it was put there *before* the date of his departure via the time machine. But if that were the case, Chronos could dig it up before he left, and with the proof of his machine's abilities in his hand, refuse to travel backwards in time to place the article in the ground. Thus the article would not have been buried in the past and so could not be excavated, thereby necessitating Chronos' time travelling in order to bury it, and so on. If it exists, he does not travel in time; whereas if it does not, he does. But if he does not travel in time the buried object cannot exist in the past, and if he does, it will exist (assuming no interference²). The structure may be more clearly illustrated by way of its logical form:

$$(X > Y) \ \& \ (Y > \sim X) \ \& \ (\sim X > \sim Y) \ \& \ (\sim Y > X)$$

(where $>$ indicates implication).

(V) Next arose the problem of identity, as Chronos met and communicated with his later self. It is a necessary requirement of any successful claim to time travel into the past that one is capable of identifying the person claiming to be a time traveller at time t_{+n} with the person who purports to be an older stage of that traveller at time t_{-n} . Without such a relation it is impossible to prove that time travel has occurred, as opposed to remarkable coincidence or form-creation. Thus Chapter 3 (unoriginally entitled *Identity*) will

2. Certain qualifications are required concerning this situation, and these will be given, together with examples and a more detailed explanation, in the appropriate chapter.

be devoted to a consideration of this topic. In it I will attempt to find criteria of identity that can fulfil the exacting demands of a time traveller as well as those of normal existence.

(VI) Finally, I described Chronos as moving 'forwards through time slowly, in order to follow the building of the pyramid through the windows of his machine'. I will now analyse this in more detail and argue that although this may be feasible when travelling in a positive temporal direction, as in this instance, it is not possible when travelling *backwards* relative to the object(s) to be observed.

The image of time travel recalled by so many who consider the subject is often that of a person inside a machine witnessing the passage of events outside the machine's perimeter, whether in a forward or backward direction, at very high speeds. Flowers grow, bloom and die; snails streak across the floor; the sun rises and sets in seconds and -- more often than not, as backward time travel is of more interest -- in the reverse direction. The reason may be a consequence of the inaccurate film version of Wells' *The Time Machine* and the wonders provided by *The Oxford Scientific Film Unit*, neither of which can be considered examples of time travel. But these images are persistent, and have not remained confined within the boundaries of popular fiction and media special effects. Jonathan Harrison, in his article *Dr. Who and the Philosophers, or Time Travel for Beginners* also speaks of the

view out of the porthole of the time machine. He writes

If there are windows in their machine, what sort of scenery may we suppose them to see? So far as their instrumental readings go of course, things happening outside the machine will seem to them to be happening in the reverse order from the order in which they would be happening if we date them by the sun....If they actually see, through the windows of their machine, then what they see would be the leaves turning from brown to green, and the sun rising in the West and setting in the East.

Harrison, 1971, pp. 11-12.

The problems inherent in this particular aspect of Harrison's thought experiment were brought out by one W. Godfrey-Smith when replying to Analysis Problem 18:

Let us ponder what happens during the journey. For the backwards traveller no sun would be visible rising in the West...; radiant energy would diffuse upward from the earth to the sun. The surroundings of the machine would be invisible.

Harrison, 1980, pp. 72-73.

Harrison's reply highlights both the potential for confusion during discussions of time travel, and the ease with which one assimilates popular imagery to the exclusion of rational debate.

Why...should the fact that, on the surface of the earth, there is a container holding a clock which is moving backwards and a body of a human being which is getting biologically older rather than younger mean that the container is invisible?

Harrison, 1980, p. 67.

The simple error expressed in this response surprised me not a little since the problem is rooted in the *backward temporal direction* of the time machine, not in the clock or the biological details which are both irrelevant to this matter. It should be recalled that whenever film companies employ special effects to give the *impression* of time travel, they merely run the film through the camera in the reverse direction thereby giving the appearance of time running backwards. However, the fascinating and often highly amusing nature of these images belies the ease with which they were presented to us. Once the film has been made in the normal manner (or using stop motion photography in the case of plants or slow moving objects), there only remains the simple matter of threading the film through the projector in the opposite direction or, in these days of video recorders, pressing the reverse button, for the effect to be created. However, the success of this imagery is dependent upon the fact that genuine time travel is not taking place. The time traveller is not watching a film, but attempting to observe photons that are moving away from the machine because of the latter's

temporal direction. This is not to suggest that the existence of an object moving in the opposite temporal direction causes photons to reverse their course, but simply to recall that, relative to that object, their direction is reversed, just as, relative to an outsider attempting to peer into the machine, the light rays emanating from it would also be reversed. The time traveller and the external observer could no more see the outside world or the interior of the time machine respectively, than a normal observer could see the light being dragged away from them by a black hole. Thus the view from inside the machine when travelling backwards would be non-existent, and a similar condition would apply to any person outside the machine trying to see in. At this point the association with backward causation becomes clear. For in order to claim that Chronos could examine the surroundings of his ship during backward temporal movement, it is necessary to assume that he would see the effects before the cause, i.e., the light from the sun before it is given off. Here it should be recalled that regardless of the machine's temporal course, the behaviour of the person inside it will always appear normal *to him*. This is because both he and the machine are travelling in the same direction. To use a spatial analogy, we do not notice the incredible speed at which the planet Earth travels through the universe because we are travelling with it at the same speed. Difficulties can only arise when Chronos attempts to examine something that is travelling in the opposite direction to himself -- in this instance, anything

outside the boundaries of the time machine.

Thus within the machine the causal direction is from cause to effect, but when travelling backwards the causal direction outside the machine, from the perspective of the person inside it, would be from effect to cause. What would happen if a case of backward causation and one of ordinary causation met? This is a factor which must be taken into consideration as it appears an inevitable consequence of Chronos' activities, most clearly witnessed at the windows of the machine. A possible answer to this was provided by an article in Scientific American (No. 77, Jan. 1967) called '*Can Time Go Backward?*' where the author (Martin Gardner) considered the potential experiences resulting from an attempt to examine a time reversed universe. He writes that

...a time-reversed galaxy would be invisible to us because light would flow into it instead of out.

Gardner, 1967, p. 98

Later he explains the physical reasoning behind this claim, arguing that

it is easy to observe a reversed world -- one has only to look into a mirror. But how could an observer in one galaxy 'see' another galaxy that was time reversed? Light, instead of radiating from the other galaxy, would seem to be going toward it. Each galaxy

would be totally invisible to the other³. Moreover, the memories of observers in the two galaxies would be operating in opposite directions. If you somehow succeeded in communicating something to someone in a time-reversed world, he would promptly forget it because the event would instantly become part of his future rather than of his past....Norbert Wiener, speculating along such lines in his book *Cybernetics*, concluded that no communication would be possible between intelligent beings in regions with opposite time directions.

Ibid., p. 102.

But in the thought experiment I outlined at the beginning of this chapter, Chronos was moving forwards through time, and so it would appear that the above arguments do not apply. Would he, therefore, be capable of witnessing events outside the machine and, of equal interest, would those outside the machine be in a position to watch him? If time travel into the future is achieved via cryogenics or a form of hibernation then clearly there would be no problem for those outside the machine who wish to see in. The machine would continue to exist upon the surface of the planet in the normal manner; hence views would be possible, unless the means employed to prevent damage (either as a result of natural or man-made activity) occurring to the machine, before the intended moment

3. There may be means by which we can determine the location of the entrance to a time reversed universe by effects on the boundary between the two universes, but normal views would be out of the question.

of arrival was reached, inhibited the view. Under this description, though, Chronos himself would not be capable of watching the passage of events outside, which was an important aspect of the description above; consequently the method employed must preserve Chronos in a conscious state in order that he may experience the passage of events in his immediate vicinity (i.e. within the confines of the machine) in the normal manner. However, I believe that once this qualifier has been added, the method utilised for time travel into the future will prevent both viewpoints from being realised. In order to explain this, it is necessary that some consideration be given to modern scientific theory, although I will try to keep this analysis as brief as possible.

One of the stranger consequences of Relativistic Theory concerns 'time dilation'. At speeds on or above 60% of that of light, or near exceptionally high gravitational fields (a black hole, for instance), time slows down perceptibly for the object concerned relative to observers not experiencing the effect. An example of this form of time dilation (or dilatation) regularly appears in the shape of certain particles whose very existence on the surface of the planet Earth would not be possible, were it not for the fact that the particles (mu mesons or muons) *had not experienced* the time required for them to travel through our atmosphere. Even at the speed of light the journey time is such that they should have decayed before reaching the planet itself. The fact that they have not is indicative of the actual passage of time for

the particles -- a period of sufficient brevity to enable their existence to be registered by instruments on the surface. Similarly, for an object approaching a black hole the theory predicts that the massive gravitational field will slow all clocks (including biological ones) until, as the subject fades from view (having never crossed the event horizon from the observer's point of view), they almost, but not quite, stop relative to an observer not caught in the gravitational field. Of course, in neither example does the subject of the experiment notice any difference in time as it affects himself.

From these examples it appears that a conscious time traveller into the future must either achieve near light speed, or he must position himself near an intense gravitational field. In neither eventuality can he remain upon the surface of the planet, and the only external observers who would be in a position to examine his behaviour inside the machine would either have to be travelling with him or be alongside him as he neared a black hole or similar gravitational field. In each case the observer is experiencing the same conditions as the traveller, and so cannot be said to be in an equivalent position to that of the imaginary observer, on the surface of the planet, attempting to peer inside the machine from the perspective of his different physical state. As for the traveller's view, it would appear that his experiences would match those predicted by the relevant theory, and would depend upon the relative velocity

of the objects to be observed.

One more possibility remains. This would involve the slowing of Chronos' biological clock in such a manner that he ages more slowly but nevertheless remains conscious and so is free to witness the (apparently) high-speed passage of events outside. In contrast, those outside the ship would be able to peer in and see the (apparently) immensely slowed behaviour of the traveller within. Whilst this successfully fulfils both requirements it is at an unnecessary cost since there is no known means whereby this could be achieved. On the other hand, two methods for travel into the future have been presented which are, in principle if not yet in practice, possible, although neither permits a symmetrical view. Hence there are good reasons for supposing that neither when travelling backwards nor when travelling forwards through time would the traveller be in a position to watch reversed or high-speed temporal passage around him.

The above arguments further undermine Dummett's claims regarding the necessary apparatus required for time travel into the past, since not only will the physical method employed necessitate the movement of the machine through space, but, even were it to remain on the surface of the planet, a backward-moving machine would not be visible and so the positioning of its earlier self could not be determined by means of observation. However, Dummett's point regarding the positioning of the machine is not altogether redundant, as will now be shown.

Imagine Chronos inside his machine, travelling through space in a linear manner, preparing to press the lever which will send him backwards through time. If he does not move instantaneously in space at the precise moment when he begins backward temporal movement, an overlap will occur as the back of the machine occupies the same space-time as the front of the machine the instant before. This situation would also have arisen had Dummett employed his crane method, except that in his case the top and bottom of the machine, rather than the front and back, would have been affected. From this it may be deduced that either the time traveller must utilise a method which ensures that at no point during his journey does the machine move locally in a backward temporal direction, or the entire machine must be physically relocated at the instant it begins its journey into the past. Both of these alternatives will be considered in greater detail in the last chapter of this thesis.

Having highlighted the component parts of the thought experiment and distinguished those that require further examination, I will next provide an explanation of the ordering of the chapters in this thesis.

Section 3

Method of Analysis

The study will begin with an analysis of *Personal and External Time*, to be followed by the chapters on *Identity*, *Freewill and Determinism*, and *Causality*, in that order. Each chapter will deal specifically with the subject of its title, although the interconnected nature of the philosophical problems associated with time travel (an aspect which has already come to light in this first chapter) will force an occasional repetition in order to provide greater clarity. But if the problems are so interconnected, their arrangement should make no material difference. Some explanation would therefore seem to be in order.

The first draft of this thesis began with problems of freewill and determinism. This was because I had been preoccupied for many years with the implications of time travel upon the freedom of rational beings. Having studied the subject further, I have come to realise that although problems of freewill may seem more pressing, it is problems of causality that will prove fatal to the project. For whilst the former are psychologically disconcerting, they generate neither incoherence nor logical contradiction, in stark contrast to the results of my investigations into the problems of causality.

The association between causality and time is such as to have led some to suggest that the two are almost synonymous;

the argument is appealing, as this analysis will show. For the present, it is only necessary to recognise that any consideration of causality as it pertains to time travelling activities will necessarily contain considerable complexity within its boundaries. It is therefore left until last, at which stage other strands defended in this thesis will have been explained and so can be drawn upon to simplify the analysis. In addition, the chapter will become both a study in its own right and a résumé of all that has gone before.

As to the ordering of the remaining chapters, the consideration of alternative temporal reference points will be examined first because of the fundamental nature of the attack and the ease with which it is levelled. Once an acceptable solution to this problem has been found, the study will move on to consider the problem of identity before that of freewill. This is due to the fact that it is necessary to prove an identity relation between the person entering the time machine at one moment, and the person who, centuries earlier, claims an identity relation with that individual, if problems of freewill are to arise at all. Freewill and causality will follow in that order, followed by a summary of the arguments and conclusions of each chapter. From this study I hope to provide a greater understanding of what is, at best, a highly complicated subject, touching as it does upon one of the most used and yet least understood aspects of human existence: time.

Chapter 2

Personal and External Time

*He may even now -- if I may use the phrase --
be wandering on some plesiosaurus-haunted Oolitic coral
reef, or beside the lonely saline lakes of the Triassic
Age...*

Wells, 1982, p. 283.

*To travel in time is to traverse some
temporal interval in a time that differs from the
duration of that interval. Thus we have a
straightforward contradiction.*

Horwich, 1987, p. 114.

This chapter will be concerned with the resolution of the above contradictions, by means of the introduction of relative frames of temporal reference. I will demonstrate that a more rigorous linguistic style, which clearly distinguishes the temporal frame of each of the objects under consideration, can dissolve those attacks upon the logical possibility of time travel that the above exemplify. I further hope to show that, without these reference frames, many of the most commonly uttered descriptions of time travelling activity become meaningless, and so inadmissible as evidence of the subject's 'prima facie incoherence' (Flew, 1988, p. 267).

The assumption that time travel is 'obviously'

contradictory, as a result of the temporal disagreements that arise during discussion of the subject, has become so widespread that it is sometimes mentioned as an aside or prelude to another argument. Thus Flew writes

...quite apart from all the contradictions involved in such experiences as those of being witness in 1987 to a battle which occurred in 1066, or of being directly affected by the happening of things which have not yet happened, the time traveller would have to be not a flesh and blood human person but a disembodied soul. And it is not to be taken for granted that that suggestion is any more coherent than the others.

Flew, 1988, p. 268.

The resolution of this problem is vital to any future analysis of time travel. If it should prove impossible to re-interpret all allusions to this activity, by means of an appeal to alternative temporal reference points, without serious detrimental consequences for the writer's initial intent in making the comment, then it will follow -- should no other alternative present itself -- that such descriptions of time travel are indeed inherently contradictory and therefore nonsense.

Section 1

The Problem

Dennis Charles Holt, writing on what he terms *The Time Discrepancy Paradox*, gives the following clear example of the problem under consideration.

[I]f he [the time-traveller] travels from the last day of 1981 to the last day of 1982 in fifteen minutes, he will arrive at his destination both fifteen minutes and one year after he departs; if his journey is instantaneous, his arrival will take place immediately after but also one year after he departs; if he journeys into the past, he will depart before, but also after, he arrives. This is an essential, indeed a definitive, feature of time travel as it is popularly conceived.

...But now that it is made clear what the time discrepancy unique to time travel is, it seems necessary to conclude that time travel is not possible.

Holt, 1981, pp. 1-2.

The key to the resolution of this problem manifests itself if Holt's argument is rewritten to bring out the logical structure.

Premise 1. In a description of time travelling activity, X uses a time machine to travel one hundred years in the positive temporal direction.

Premise 2. A period of five minutes elapses inside the machine, whilst outside the period is of one hundred years.

Premise 3. Five minutes have elapsed between the start and the end of the journey *and also* one hundred years have elapsed between the beginning and the finish. This is a contradiction.

Conclusion. Time travel necessarily entails the contradiction stated in premise 3, therefore to time travel is to attempt to perform an act that is self contradictory.

There are three points of note here. The first is that Holt makes the assumption that his depiction of time travel is the only one that accurately describes the method of temporal relocation intended by authors on the subject. Second, although Holt makes occasional references to time travel into the past, his argument is primarily built around examples of future-directed temporal movement. In concentrating on such examples, however, he avoids a direct confrontation with a key element of time travel, and it is this element that undermines his claim to be the only person who is discussing genuine time travel when he is challenged by the arguments of philosophers such as Horwich and Lewis. Third, in the above it was clearly specified that a period of five minutes had elapsed *inside the machine*, whilst a period of one hundred years had elapsed *outside it*. Consequently, it is necessary to make a distinction between the time outside the boundaries of the time machine, with respect to which the traveller is moving -- this will be

termed the external temporal reference -- and the time period experienced by Chronos within the machine, that is the period taken to complete the journey -- this will be termed the personal temporal reference. No such distinctions are made by Holt and, indeed, his entire argument is built on the claim that there is only one frame of temporal reference.

It is in an analysis of this last point that a unification and resolution of all three points will be found. There are indications that the descriptions based on the external and the personal time frames are not merely different phrases for the same experience -- except in the trivial sense that both refer to the passage of time -- but refer to distinct and definable spheres of temporal reference. However, the most obvious indicator is the disagreement between the two in cases such as that under discussion, and this appears to lead into a circular argument. The onus is therefore upon me, as the proponent of this solution, to prove both that the distinction drawn is not an arbitrary one and that there is justification for its application.

The pragmatic need for two temporal frames of reference becomes apparent when it is recalled that neither the time traveller nor his machine can lose or age the relevant number of years in the negative or positive direction when travelling backwards or forwards in time¹. This is because,

1. No time travel story to my knowledge raises this issue unless it is as a result of

were such temporal losses or gains to occur, time travel into the past that encompassed periods greater than the age of the oldest then living human would be impossible, and even that person's observations would be useless if they were too young by the time they arrived to remember them. Similarly, time travel to any period earlier than the date of the completion of a fully functional time machine would also be impossible because it would cease to work, being at that moment incomplete, rendering its invention useless to those first potential time travellers. This would also generate difficulties for the (otherwise relatively unproblematic) concept of time travel into the future on those occasions when the aim is achieved without the appliance of cryogenics or any other method that utilises similar temporal relationships between the 'traveller' and his surroundings; here, the age and fitness of the traveller will determine the length of the journey, it being curtailed by death through natural causes or through the hastening of latent disease.

It would be reasonable to enquire at this stage whether only two frames of reference are sufficient. J.W. Dunne, in his book *An Experiment with Time*, is of the opinion that they are not, and to justify this belief he subjects one of his own paragraphs to closer examination. There he notices the tendency in his speech to refer to what appears to be another time.

machine error, which -- by definition -- is not the system of time travel being examined.

That this 'present' field of observation moved in some queer fashion along the Time length; so that events which were at first in the future became present and then past. The past was thus constantly growing.

Dunne, 1958, p. 110 (his emphases).

He argues that such references, which seem to indicate a time within a time, are

the legitimate consequence of having started with the hypothesis of a movement through Time's length. For motion in Time must be timeable. If the moving element is everywhere along the Time length at once, it is not moving. But the Time which times that movement is another Time. And the 'passage' of that Time must be timeable by a third Time. And so on ad infinitum.

Ibid.

Since I only make appeal to two temporal references, I must disagree with the claim that one must inevitably succumb to an infinite regress. This disagreement derives its substance from the fact that the necessity of two temporal reference points originates in the discrepancies experienced by the traveller on those occasions when he moves through time in any manner other than that experienced by all objects that are not time travelling. Additional reference points will

only be required if further discrepancies arise between the personal and external time frames and some previously unknown temporal measure that cannot be satisfactorily explained in terms of those two time frames. If such discrepancies should not arise, once the measurements of temporal passage agree with one or other of these references, any repetitions may be ignored as surplus to requirements. Now, according to Dunne's analysis above, repetitions will only occur in the measurement of personal time, because it is to this reference that we make appeal when measuring the duration of the traveller's personal experience of his 'motion in [external] time' -- in this instance, into the past. It is a tautologous fact, however, that an individual's particular experience of the passage of time cannot differ from that experienced by the individual, and therefore, since the criterion for multiple frames of temporal reference -- that the temporal measurement concerned does not agree with that of either the external or the personal time frame -- has not been fulfilled, no further temporal references are required.

On a more fundamental level, the error in Dunne's argument arises because he has allowed his language to shape his ideas, rather than using it to express them. In effect, he has succumbed to an aspect of the misconception of time that is commonly referred to as the Myth of Passage. This appears to have developed from a complication in day-to-day parlance in which people refer to time as though it were a

medium through which one travels, like a river. The problem arises because the imagery dominates the argument, encouraging otherwise meaningless questions such as 'how long does it take the river of time to flow past a certain point?'. Although undeniably tempting, it is a misleading image; in this instance, this can be illustrated by the fact that it is possible to express, in a logically coherent manner, the movement of a person through time by using a simple graph that does not appeal to more than two temporal references. In Fig. 2.1 (loosely, though not entirely, based on Lewis's description: see below) the direction of the passage of external time is indicated by the arrow along the Y axis, while the direction of the passage of personal time is indicated by the arrows on the line representing the traveller². On those occasions when the arrows on the traveller's line go in the opposite direction to that indicated by the Y axis, he is travelling backwards relative to the external temporal reference, while still experiencing the normal passage of personal time. He would not, therefore, appear to someone inside the machine with him to be behaving in an unusual manner -- for example, removing dry tea bags from a pot in which clear boiling water remains. In contrast, if, *per impossible* (see Chapter 1), someone could watch his activities from a temporal

2. I have not included calibrations on either the personal or external time frame indicators because of the difficulty involved in accurately applying them later in this thesis. Key events in the traveller's life with which the discussion is concerned will be marked directly on the graphs, but the passage of time between the events will not be accurately represented -- merely the relative temporal positions.

perspective running in the opposite direction (i.e. from the external viewpoint), that is precisely what would appear to occur. The problems inherent in the Myth of Passage will be reconsidered in Chapter 5; at this stage, however, the words of David Lewis may aid the understanding of the time traveller's graphical representation under the present description.

A time traveler, like anyone else, is a streak through the manifold of space-time, a whole composed of stages located at various times and places. But he is not a streak like other streaks. If he travels towards the past he is a zigzag streak, doubling back on himself. If he travels towards the future, he is a stretched-out streak. And if he travels either way instantaneously, so that there are no intermediate stages between the stage that departs and the stage that arrives and his journey has zero duration, then he is a broken streak³.

Lewis, 1986, p. 69.

3. It should be noted that, although Lewis makes no specification, the gap would only appear in a graph representing the external time frame alone. The reasoning behind this claim is explained in Chapter 3.

Section 2

Analysis

Having established the hypothesis that the application of two, and only two, independent temporal references should be recognised as a convenient explanatory requirement for logically coherent descriptions of successful temporal movement into the past or future, it would now be appropriate to test whether or not it is also a necessary condition of such activity. We are already aware that travel into the future is, in theory at least, possible using Einstein's theorems (see the Introduction and Chapter 1), and that the measured period of time experienced by that which is travelling differs from measurements made by non-travelling instruments. It is clear, therefore, that there is some genuine and existent difference between the temporal reference with respect to which the time traveller is said to have moved, and the time experienced personally by him inside the machine as his external temporal relocation is taking place. However, a re-examination of Holt's thesis reveals that he does not accept such appeals to Relativity Theory as an argument. He mentions the effect of speed upon the decay rate of mu mesons, but then adds that

[t]his result is not relevant to the problem of time discrepancy... unless one should allow that high speed mu mesons succeed in traveling through time in the originally conceived sense, and it would be

ridiculous to suggest that that is what the mu mesons do in this instance. Nowhere in the passage is it suggested, nor is any basis to be found for thinking, that in virtue of their high velocity the mu mesons temporarily outdistance the observers measuring the rate of decay. Wellsian speculations about the whereabouts of the time traveller are thoroughly out of place here, and so the time discrepancies associated with special relativity are simply irrelevant to the problem of time discrepancy associated with the idea of time travel.

Holt, 1981, p. 5.

Holt's dismissal is rooted in his interpretation of the so-called 'twins paradox' which he does not consider to be a genuine instance of time travel. While I will shortly be taking issue with his definition of time travel, his argument does not directly affect my claims at this stage. Whether or not the behaviour of atomic clocks or mu mesons can be termed genuine instances of time travel is irrelevant to the fact that they do indicate the existence of equally legitimate and independent temporal measurements, whose discrepancies need not entail logical contradiction. For an independent human observer on the surface of the planet, using highly accurate clocks, more than three micro-seconds elapse between the initial entry of the mu mesons into our atmosphere and the registration of their existence upon the

surface of the planet. Had the same amount of time passed for the meson, however, it would have decayed. It has not, and therefore the meson must have experienced an interval which is less than that critical period. Similarly, atomic clocks at high speeds, or at greater distances from the centre of gravity, also register slightly different results from those left upon the surface of the planet, and both these measurements are equally valid from a scientific point of view.

If it is clear that these two frames of temporal reference are different, then what grounds remain for the claim that there exists a contradiction when the two disagree? The incorrect reasoning behind this assertion appears to stem from a failure in verbal distinction. Because both references are simply termed 'time', without any further qualification, the way is made easy for an equivalent failure in logical distinction. Once again, it is Lewis who outlines the difference.

With respect to the correct assignment, properties change continuously as you go along, for the most part, and in familiar ways. First come infantile stages. Last come senile ones. Memories accumulate. Food digests. Hair grows. Wrist-watch hands move. The assignment of co-ordinates that yields this match is the time traveller's personal time. It isn't really time but it plays the role in his life that time plays

in the life of a common person. It's enough like time so that we can -- with due caution -- transplant our temporal vocabulary to it in discussing his affairs. We can say without contradiction, as the time traveller prepares to set out, "Soon he will be in the past." We mean that a stage of him is slightly later in his personal time, but much earlier in external time, than the stage of him that is present as we say the sentence.

Lewis, 1986, p. 70.

Lewis emphasises the personal time frame's dependency on the existence of the external time frame, deriving from that his claim that personal time 'isn't really time'. Whether or not the personal time frame can be called 'time'⁴, however, does not affect the fact that, in the above words, Lewis lends support to the resolution of the problem of time travel's contradictory nature through the use of a binary system of temporal references. As Horwich writes:

Giving up the notion of absolute time and relativizing time to frames of reference allows us to view the 500 years of earth time [in his example] and the 15 minutes of the proper time of the time machine as equally good and correct measures of the temporal difference between the year 2500 and the departure of

4. Since it plays the same part in the traveller's life the difference is purely academic.

the time machine.

Horwich, 1987, p. 114.

But what of Holt's claim that such an argument is faulty because it does not recreate the state that must necessarily exist in order that time travel can be said to have occurred?

The 'Twins Paradox' is a conundrum arising from the time dilation associated with travel at speeds nearing that of light. Thus one twin, Peter, accelerates away from the Earth at sub-luminal velocities far in excess of those presently achieved by mankind, and then turns around and powers back to the planet. Meanwhile the other twin, Paul, remains on the planet awaiting his brother's return. Holt claims that

[f]rom the perspective of Paul, the stay-at-home, the narrative of Peter's journey, if it is an authentic journey into the future, will proceed roughly as follows: Paul says goodbye to Peter as Peter boards his rocket ship; Peter accelerates away from earth; six months later Paul writes in his journal, "If all has gone well, Peter has now returned to earth 19 years and 6 months from now." Likewise, Peter's perspective, as he arrives on earth, will be conveyed in words such as these: "Paul must now be wondering 19 years and 6 months ago whether I have safely arrived."

Holt, 1981, p. 5 (his emphasis).

Holt rightly argues that such claims are not sanctioned by relativistic theory, since the passage of time, according to that theory, can only be measured relative to the individuals speaking: Paul physically experiences the six months that have passed for him in the rocket ship, while remaining intellectually aware that twenty years have passed for his twin, Peter, on Earth. However, Holt then goes on to argue that time travel must necessarily not use such frames of reference, since then it would not, in his opinion, be time travel. In response to the arguments, propounded by Horwich and Lewis, for the application of relative frames of temporal reference, he writes

Suppose I say that one can travel ahead in time by taking the plane from San Francisco to New York. (Six o'clock comes fewer hours after the time of departure, say eight o'clock, as measured by my wrist-watch, than it would if I had stayed in San Francisco.) And suppose someone issues the complaint: "But you are not talking about authentic time travel"? What have I won by responding "But of course I'm not talking about your silly naive notion. I am talking about a sophisticated notion of time travel"? If there is sophistication here, it is only in my willingness to play loose with language, a certain cleverness with words. It seems to me that Horwich and Lewis, and others of like inclination, do something exactly

parallel to this -- though it is somewhat obfuscated by all the talk about alternate models of time.

Ibid., p. 15.

The system of time travel that Holt demands necessarily invokes contradiction, and he refuses to acknowledge the solution of Lewis and Horwich on the grounds that he alone is discussing genuine time travel, and they are merely 'playing loose with language'. If that were genuinely the case it would be futile to make further appeals to alternative temporal references because, in so doing, one would no longer be discussing time travel and, consequently, any subsequent argument would be irrelevant, except inasmuch as the phrase 'time travel' would be employed by all the protagonists. With what justification, therefore, does Holt maintain that his definition is the only correct one? Is it his specification -- one that is never clearly stated, but must instead be derived from an analysis of his argument -- or that of his attackers that is favoured by authors in the subject?

The quotation from Wells at the head of this chapter appears to be a clear example of Holt's definition of time travel, but since this is the earliest science fiction tale on the subject to have achieved world-wide recognition, the logical lapse might legitimately be put down to a lack of thought on Wells' part in a subject which, until that moment, had received almost no attention. It should,

however, be borne in mind that even Wells qualified his statement with the words 'if I may use the phrase', so there is some justification for the inference that he, too, felt uncomfortable with his expression. Wells' short story may be reconsidered in due course, but since then a number of books and films have considered the subject. If these also fail to avoid the paradox that Holt deems a necessary feature of true tales of time travel, then it is up to his antagonists, rather than Holt himself, to prove that their description of time travel is the more accurate. Clearly it would be an impossible task for me to read every known science fiction work upon the subject, but a random selection may be sufficient.

Robert Heinlein's short story *All You Zombies* makes every effort to avoid Holt's paradox. The time travelling event itself appears to be instantaneous (no mention is made of time spent during the journey), thereby avoiding that aspect of the problem, and at the head of every section that occupies a different moment in time to that of its predecessor there is given a clear temporal reference: the first is '2217 Time Zone V (EST) 7 Nov 1970 NYC'; the last is '2200-VII-12 Jan 1993-Sub Rockies Annex-HQ Temporal DOL' (Heinlein, 1980, pp. 126-138). Consequently, in each case the word 'now' has been given a clear temporal reference, and no instant has temporal priority. The lack of temporal priority is due to the entirely self-supporting and self-generating nature of the main character, whose personal

world line is closed, and this provides a clue to Heinlein's preferred number of time frames.

In order that a closed causal loop, or closed world line, can exist, it is necessary that information -- in this example in the form of memories and DNA -- be preserved during a journey into the past. This would not be possible with only one time frame, because information would be lost as the traveller, having only one time frame relative to which he can age and with respect to which he is also travelling in the reverse direction, would grow younger as he travelled backwards through time. Furthermore, the instantaneous nature of the system used by Heinlein's traveller would not be possible, because a journey of thirty years into the past or the future would have to take thirty years to complete -- there being no reference frame relative to which the journey could be instantaneous. Consequently, time travel into the future, using any method other than those that slow biological processes, would not be possible. Time travel into the past would also be impossible because, for every year the traveller attempted to move into the past, a year would advance: as he attempted to move into the past all memories and marks inappropriate to his temporal location would be lost, and as he was carried into the future they would be regained. The cumulative effect would be the absence of time travel, as every reverse movement would be counteracted simultaneously by a positive temporal advance. Nothing would happen, or be recalled, that could

indicate any temporal movement at all. Under such conditions, Heinlein's story would never have been written.

In *By His Bootstraps*, also by R.A. Heinlein, there appears the following quotation.

He was standing at the top of a broad steep ramp which spread fanlike down to the base of the building...It was the same placid, lush, and familiar scene he had looked over when he breakfasted with Diktor -- a few hours ago and ten years in the future.

Heinlein, 1959, p. 76 (my emphasis).

The highlighted section appears to be a blatant contradiction that is in keeping with Holt's argument. Yet, once the preceding script is read, it becomes plain that the writer is appealing to two frames of temporal reference: a few hours ago relative to the personal time frame; ten years in the future relative to the external time frame. The traveller's memories, and the contents of his stomach, bear witness to his having breakfasted in the last few hours, but since enjoying that meal he has used a time machine to transport himself ten years into the past. It is because an event that is going to occur in the future, relative to his immediate temporal location, is already a part of his causal history, that the apparent contradiction emerges. Yet both his satisfied appetite and his memories can only be preserved if the temporal arrow and causal history of the traveller are always positively directed relative to him,

otherwise he would have neither his memories nor his full stomach because the events would not have occurred in his past. It follows, therefore, that in this story also two relativised frames of temporal reference are a necessary feature of the system of time travel to which Heinlein subscribes. In these examples, therefore, Holt's arguments do not apply because these are not instances of time travel as he defines it.

Robert Silverberg, in his short story *Sailing to Byzantium* (Dozois, 1989, pp. 85-154), gives temporal references for his statements in the shape of the indigenous people of the future (for the purpose of the present discussion this may be understood as the external temporal reference), and the 'visitors' (here understood as the personal temporal reference since in this case the visitors are the time travellers). The visitors have been (apparently⁵) removed from their own historical periods in order to become entertaining anomalies in a future where all time periods can co-exist in the form of recreated ancient cities. Within this framework there appear the following phrases: 'And then there were all the cities like New Chicago, out of time that was time yet unborn to him but

5. Later the hero discovers that he and all the other 'visitors' are also creations of the future, each based on information gleaned about people from earlier times -- in his case, about a man of the 20th century living in New York. This does not, however, affect the argument, since the visitors believe themselves to be from the appropriate positions in the past and base their phraseology on that belief. Were they aware of their actual temporal origins, it would be fair to assume that they would apply the appropriate temporal references in the same manner that those from the 50th century do throughout the tale.

ancient history to them' -- 'him' being the visitor from the 20th century and 'them' being the occupants of the 50th century; or again, in reference to Queen Elizabeth II to a visitor from the 16th century, 'A second one, and not much like the first. Long after your Virgin Queen, this one. She will reign in what you think of as days to come'. But on the same subject Silverberg also writes 'There will be another of her name in England, in due time. Has already been in fact' and this appears to invoke Holt's paradox. However, when the context is examined it becomes clear that the first reference is to be understood as being from the perspective of the 16th-century visitor, while the second is in reference to the perceptions of the 50th-century inhabitants.

Andrew Weiner's short story, *Klein's Machine* (Dozois, 1989, pp. 189-205), has a psychiatrist trying to jolt the memory of an alleged time traveller by means of a drug-induced hypnosis. Under these conditions the subject is encouraged to re-live the moments of his time journey into the future. Weiner writes

'Philip...I want you to think back to the night of July 5th. Do you remember that night?'

'Of course,' Philip said. 'Tonight's the night. The night I test my machine.'...

'What's happening, Philip?'

'I don't know, I don't remember...'

'Go with it, Philip...You remember the future. You're there now. In the future now...'

Dozois, 1989, p. 199.

The last phrase in particular (being the closest the story comes to generating the paradox demanded) appears to fulfil Holt's criterion, but the individual in question is, in fact, neither travelling through time, nor physically occupying, at the same person-stage (see Chapter 3), both the present and the future at the moment the phrase is uttered. The psychiatrist is attempting to make his subject recall an incident which lies in the latter's memory, and so he takes Philip through his memories until those that include future events are reached. He then encourages Philip to recall those memories verbally by making him experience them again mentally while in the psychiatrist's office. Hence the apparently illogical claim that he is 'in the future now' means that the memories he is presently recalling are those of events that lie in the external future. This type of language is one often heard in cases of hypnotic regression techniques, but in this case, due to the utilisation of a time travelling method, the memory happens to be of events in the future rather than in the past. Once again, the need for a relativised frame of personal temporal reference ensures that Holt's claims do not apply.

The personal time frame must preserve the memories of events that have already been experienced by the time

traveller, but that lie in the external future. Consequently, the ordering of local cause and effect must always be positive for the traveller, regardless of his temporal destination. How does this explain the need for two frames of temporal reference? If time travel into the past is intended, it may be argued that this positive causal order could be preserved by simply reversing the causal order for the time traveller as he travels into the past. However, the mere reversal of the ordering of cause and effect does not create time travel (see: Mellor, 1981, pp. 172-177; this thesis, Chapters 3 and 5), and, therefore, the temporal aspect is still required. As backward causation does not counteract the need for two time frames, its introduction would be an unnecessary complication. If the ordering of cause and effect is reversed relative to the external time frame, then it is positive relative to the personal time frame, and is, therefore, equivalent to the system of time travel defined in the introduction. On the other hand, if the ordering of cause and effect is reversed relative to the personal time frame of the machine, it must be positive relative to the external time frame. This, in turn, would mean that the machine would be operating before it had been switched on, because the fact that it is operating would be the cause of its being switched on at some point in the future relative to the external time frame. But if it has not yet been switched on, it cannot operate. Under standard descriptions of backward causation

the operation of a machine would be the cause of its being turned on, but the moment at which it was turned on would lie in the past: when describing time travel into the past, the operation of the machine would physically precede the moment at which it is turned on, consequently it would not operate. In effect, reversing the temporal direction relative to the external time frame, and then reversing the ordering of cause and effect relative to the reversed personal time frame, results in a double negative, and any effort to travel backwards in time would be instantly halted, the programme having never begun. In order that needless complications may be avoided, and time travel can occur, the positive direction of local cause and effect (and all those features that, in the words of Lewis, play 'the role in his [the time traveller's] life that time plays in the life of the common person') must be preserved for the machine and those within it, but globally the moment of arrival must be previous to the moment of departure. Methods by which this may be achieved -- such as worm-holes or the Gödelian structure of space-time -- have already been proposed within the scientific community, and so may lend support to the theory. None of the writers cited has made any appeal to these methods, of course, but then each is primarily concerned with the consequences of time travel, as opposed to the method by which it may be achieved. Shortcuts that, in the realm of fiction, preserve all the necessary requirements, are therefore satisfactory, even

though there appears to be no means by which they might be physically realised. It is the fact of a system of time travel that preserves memories and consequences of future events with which these writers are concerned: the specific structure and working method of the time machine itself can be blurred for the purposes of the narrative.

In each of the science-fiction examples cited above, the authors have simply not been talking about time travel, as defined by Holt, at the moment when the apparent paradox arose. Even the example cited from Wells at the start of this chapter may also be qualified in such a way that the paradox is resolved, and the fact that the time traveller, upon returning from the future, is in a position to recount his experiences to his friends (showing that he has been able to preserve his memories while travelling backwards in time) indicates Wells' implicit assumption of a relativised system for his story. In order to fulfil the aforementioned criterion, and so resolve the ambiguity of the speech, Wells would have to rewrite the section along the following lines:

'The traveller left more than five minutes ago by my watch. Since he is using a machine that can speed up and/or reverse the passage of time around it, from the perspective of the person inside it, while preserving the normal passage of time and the ageing processes of the traveller within the machine, after five minutes had passed according to his watch, he could have stepped out of the machine to find that any number of years had passed in the time frame with

respect to which he was travelling. Hence upon emerging after his journey he might find himself wandering on some plesiosaurus-haunted Oolitic coral reef, or beside the lonely saline lakes of the Triassic Age...'.⁶

While this resolves the problem of logical coherence, it does so at the cost of literary style -- sufficient reason, perhaps, for Wells simply to apologise for the terms rather than explain them in full.

Holt might argue that I have selected only those stories that support relativised frames of temporal reference, or that I have illegitimately re-interpreted the words of Wells in order that the paradox may be resolved⁶, but is his case any stronger? He argues that a genuine instance of time travel would require that

[i]f the time traveler departs at t_0 and arrives at his destination five minutes later, and if the time at which he arrives is forty years after his departure, then the time of his arrival as reckoned by his own clocks and calendars and by the clocks and calendars of the stay-at-home is both t_0 plus five minutes and t_0 plus forty years. If, as the stay-at-home would say, the time traveler is not⁷ exploring the world forty years in the future, then he is now

6. In fact I read through 14 short stories on the subject of time travel -- including Wells -- and one novel, and could find no other examples of the paradox apart from those cited.

7. Presumably this is a typographical error in the published manuscript and should read 'now'.

exploring the world and at the same time he is forty years from now exploring the world. In the first case an inconsistency makes its appearance, in the second something closer to gibberish. In either case it does not seem that one is describing a possible state of affairs. But since just these kinds of time discrepancies are definitive of authentic time travel..., one should, it seems, conclude that time travel is not possible.

Holt, 1981, p. 2 (his emphases).

Later he claims that, were a time traveller to travel one hundred years into the future while only experiencing fifteen minutes of those one hundred years, then, as the stay-at-home reckons the passing of time by his own clocks, the latter will surmise that the time traveller will arrive at his destination both fifteen minutes and one hundred years after he departed (Ibid., p. 7). Yet this is nonsense, since the stay-at-home would not, and cannot, say that the time traveller from the stay-at-home's point of view has travelled both fifteen minutes and one hundred years into the future. All he can say is that the time traveller has indeed travelled one hundred years into the future, since stay-at-home Paul -- if he continues with his normal existence and does not use a time machine -- will not encounter the traveller, Peter, again until after the passage of those one hundred years. Nevertheless, Peter, or

his machine, will only personally experience fifteen minutes during the journey of one hundred years, whilst Paul, as a representative of the time frame with respect to which Peter is said to have relocated, will experience every second.

The discrepancy in temporal experience is, as Holt rightly points out, of paramount importance, because it is the comparison between the experience of the person inside the machine and that of persons outside it that enables the traveller to determine whether or not he has journeyed into the future or into the past. However, the time traveller cannot personally experience both periods of time but can only compare his experience with that of others who do not use a time machine⁸, and it is here wherein the mistake lies. Holt assumes that there is only one time or temporal reference point, and that therefore any temporal discrepancy must, by its very nature, be self-contradictory. While it is true that personal and external temporal references normally agree, this does not entail identity. To be indiscernible, and so fulfil both Leibniz' criterion of identity and Holt's claims regarding the inevitability of temporal paradox in theories of time travel, the temporal references must always agree. As the examples provided above reveal, however, in the case of time travel it is clear that they do not.

8. Note that no information can be drawn from a comparison between the experiences of two time travellers operating independent machines, unless they move between near-identical space-time locations. An agreed reference frame -- whether it be the personal temporal reference of two people inside one machine, or the agreed external temporal passage of two separate machines -- is required if further information on the proficiency of the machine is to be determined.

Therefore, to claim that there is only one temporal reference is simply incorrect, and if there are at least two, it follows that the paradox does not arise. Since Holt has made clear that time travel cannot preserve any logical coherence while utilising only one temporal reference, and I have argued for a resolution of the paradox -- for which there appears to be justification in the science fiction literature -- that requires two temporal references, the question arises as to whether or not Holt proves, in the course of his article, that limiting the temporal reference frames available to only one is either logically or linguistically justifiable.

Section 3

Justification?

Although there is no specific declaration of Holt's preference for one temporal reference in his article, there do appear statements that provide an indication of his hypothesis. These include phrases such as: '*Paul must now be wondering nineteen years and six months ago whether I have safely arrived*' (my emphasis, p. 5); and, during a description of the time traveller in his machine and his assistant still in the laboratory, the claim is made that the assistant cannot correctly state, after an eight-hour wait in the laboratory, that the time traveller '*has reappeared in the laboratory approximately one month hence*' (my emphasis, p. 9). The contradictory effect of these

phrases is dependent on the assumption of one, and only one, temporal reference: but are they linguistically coherent phrases in themselves? If not, they cannot be used as arguments either for, or assuming, one temporal reference, since they do not convey in themselves -- quite apart from allusions to time travelling activities -- any genuine meaning.

Upon examination it appears that the inconsistencies arising from the above phraseology originate not in the vagaries of time travel but in the manner in which the terms have been employed. Each is an example of a token reflexive statement. That is, the meaning of the words depends solely upon the state of affairs that exists for those who utter them at the moment of utterance. 'Today', if said as I type these words, means Thursday, 8 January 1993. The person reading this will mean another date by the word 'today'. Thus to say 'Now, nineteen years and six months ago' is to utter a phrase that is linguistically self-contradictory, as well as logically and physically impossible, and which is so *regardless of whether time travel is involved or not*. The sentence construction is as comprehensible as the spatial corollary 'The body which is here, in its present state, is in that room over there', and while it is common practice for individuals to employ colloquial expressions such as 'I was miles away' -- meaning that the speaker was not concentrating on the physical and temporal activities around him, but was instead thinking of an anticipated future or

remembered past event -- this is not to suggest that the individual in question, at the time of utterance, is both occupying a given spatio-temporal position and not occupying that position. The incomprehensible nature of the phraseology derives its origins from an incorrect use of English, and is not a reasoned consequence of time travel.

From the above argument it follows that Holt's assumptions regarding the existence of a solitary temporal reference are not supported either by the literature or by linguistic usage. Consequently, his attack against the possibility of time travel based in that assumption is invalid. Throughout this thesis, therefore, whenever allusion is made to a temporal reference, it will henceforth be necessary for the particular reference frame to be identified.

Section 4

Summary

In this chapter I have discussed three separate points: whether or not science fiction authors invoke the time discrepancy paradox in their writings; Holt's justification for assuming only one temporal reference; and the dangers inherent in a careless use of language. Having shown that there is not, in Holt's argument, any logical reason for limiting oneself to only one temporal reference, and being supported in my contention by experimental evidence, science-fiction preference, and the proposals of Horwich and

Lewis, I have decided to employ two distinguishable frames of temporal reference to resolve the paradox, and by that method remove one of the major obstacles to the discussion of time travel. In the next chapter I will consider a problem closely connected with that of temporal reference: that of identity over time. It is necessary that a criterion of identity be defined, and be of sufficient rigour to enable the identification of one individual, at a given instant in external time, with the person claiming that identity relation at another moment relative to that same time frame. Simultaneously, that system must accommodate for the discrepancies that must (as this chapter has maintained) exist between the traveller's personal temporal experience, and that -- measured by external time -- which should have occurred, in order that his claim to time travel may be verified.

Chapter 3

Identity

For time travel requires personal identity -- he who arrives must be the same person who departed. That requires causal continuity, in which causality runs from earlier to later stages in the order of personal time.

Lewis, 1986, p. 73.

Problems of identity are an inevitable consequence of a system that entails the possibility of a person being in more than one spatial position at the same moment relative to the external time frame. They will also arise when claims of identity are made, over a time period, between persons whose physical and mental state does not match that normally encountered over such an interval. An example of the former situation would be two people, with identical DNA and early memory patterns, standing in a room together, with one claiming to be a temporally older stage of the other. The latter circumstance might be exemplified by a person claiming identity with another who existed several hundred, or even thousand, years ago, or someone in their thirties claiming identity with a person who, at the moment of the claim, is in their teens. Any of these situations might arise in the system of time travel presently under consideration.

If time travel is to prove logically possible, it is

vital that a criterion of identity be defined which provides a simple, but all-embracing, explanation of each scenario that might be realised, while simultaneously screening out those speculations that are not based in time travelling activities. The demand for simplicity and completeness arises from the fact that every extra qualification casts doubt upon the validity of an argument -- the simplest explanations being, in general terms, the most likely. Why, then, are some systems of identity unsuitable for the time traveller?

The answer to this question depends on two features of paramount importance to time travel as presently defined. First, identity criteria that are suitable for persons who are not time travellers show a continuity with respect to external time (Lewis, 1986, p. 72). But, as was stated in the previous chapter, the time traveller shows marked discrepancies between his experience of external temporal passage and that of others who are not time travelling. Consequently, any identity criterion applied to the time traveller must accommodate for this necessary consequence of his activities. A system of identity that precluded relations to alternative temporal references would be of no use under these conditions, because it would contain within itself a denial of the possibility of time travel. Second, the system chosen must expose any instance where a claim to time travel has been made erroneously. Identity is, as Lewis points out, the ultimate proof of all such claims, and, as

such, its importance cannot be over-estimated, and its ease of understanding and use, combined with a rigorous testing method, must be a matter of primary concern throughout this chapter.

In the following pages I will initially distinguish, by means of thought experiments, the specific problems with which the test of identity will be concerned. From this survey the criterion of identity that can most appropriately be applied to time travelling activities will emerge. I will then examine some alternative interpretations that have been proposed to explain the claims of alleged time travellers, in order to determine whether or not the chosen system exposes these alternatives as spurious. Finally, an examination of the consequences of these studies for a general understanding of identity relations will be provided. In this way the system will be tested to determine its applicability to the wider problems of identity *per se*.

Section 1

Thought Experiments

The following are all potential scenarios for a time traveller under the present description. A deliberate effort has been made to refrain from any thought experiments that might involve questions of responsibility, in order to prevent the obfuscation of metaphysical issues by those of morality. The association that emerges between identity and responsibility, during a metaphysical analysis of time

travel, is not as important as that between responsibility and liberty, or identity and liberty. While each of these relationships will be mentioned briefly, in order to preserve the flow of argument, they will receive greater attention in the next chapter.

Scenario 1.

Chronos encounters a man who is considerably older than himself, and who claims to be Chronos at some time in the future. After further investigation, the older man proves to have identical memories to the younger up to the moment of meeting, and also has memories of events thereafter of which the younger Chronos was unaware, or which he was only in the process of considering. Medical analyses show that the DNA, fingerprints, and other unchanging features of a person match both men, but features that can alter or grow over time -- such as age, scars, memories, and even character -- do not.

Question. How can there exist two physically separate people who share identical DNA, fingerprints, memories (up to a point), and so forth?

Question. How can two people be of differing ages, while existing at the same time with the same DNA?

Scenario 2.

Chronos discovers a photograph that is dated, by means of chemical analysis and an examination of the subject matter, as originating in the late 1880's. It shows a man who bears a striking resemblance to Chronos. Further research reveals evidence -- such as handwriting, and statements made by the man that have been recorded -- that proves to Chronos' satisfaction that the person in the photograph is, indeed, himself, even though he has not experienced the moment the photograph was taken.

Question. How can Chronos claim identity with a person who existed over one hundred years ago, and of whom he has no memories whatsoever?

Scenario 3.

Chronos prepares an experiment with his time machine, with the aim of making several trips to the same date and hour but to different spatial locations within his laboratory. He waits in the laboratory until his intended arrival time, at which moment the room is suddenly occupied by five other time machines and five people, all claiming to be Chronos, and all appearing physically identical.

Question. How can six people, all claiming to be the same man, be in one locality at the same time?

Question. Under what circumstances can sense be made of the claim that one person is also six people?

Scenario 4.

Chronos claims identity with a man who existed 4000 years ago, of whom he has no memories, and with a man who will, he claims, appear in the laboratory the next day. Twenty-four hours later a man arrives who bears a strong resemblance to Chronos and also a resemblance to the man from four thousand years ago -- in that he exhibits the appropriate memories -- but who has aged considerably more than would be usual in the twenty-four hours that separate Chronos' earlier departure and this man's arrival. It appears to onlookers that a man from the past has contrived to remain in suspended animation until his appearance in the laboratory, while Chronos has been destroyed by his own machine. Alternatively, the man is an imposter with considerable knowledge of the scientist and the past as it pertains to the man who lived four thousand years ago, and who also bears a physical resemblance to Chronos, but who is far too old to be him. In either case identity is denied. Question. How can these identity claims be verified?

Section 2

Analyses

Analyses of the above will be based on graphical representations, that show the situations initially from the perspective of an external observer who is not a time traveller, and then from that of Chronos when making the journeys. In order to minimise both the number of

illustrations and the amount of information expressed on each one, I have applied overlays. The graph on the page is from the external viewpoint (unless otherwise indicated), while the overlay represents the personal world line of Chronos. The restrictions of two-dimensional graphics, and the demands of clarity, make it unfeasible to give the full spatio-temporal representation of the traveller when moving backwards in time, as described in the introduction. Consequently, the most direct route taken during this procedure is shown, and it should be borne in mind that the traveller would occupy a far wider area of space-time during his actual journeys, if only to accommodate for the movement of the planet (see Chapter 1, Section 2).

A cursory examination of the illustrations indicates that our inability to apply standard identity criteria in each of the examples stems from a lack of continuity in the time traveller's world line with respect to the external temporal reference. There appear to be two, three, or six individuals, depending on which image is examined, and there is no immediately apparent method by which any given world-line might be correctly connected to any other on the same illustration, assuming that such a connection is justified. If the overlays are added it becomes clear that connections do exist and are revealed through an examination of the personal time frame.

In Fig. 3.1 Chronos -- as a young man -- is indicated by line A. The link between this person and the older man

standing before him is revealed if we add the personal time line from the older man's point of view. Since A has no personal knowledge of the intervening (future, from his perspective) years, there can be no guaranteed method of deriving the required information from him. He may be able to guess his future behaviour accurately, but as information is demanded regarding more and more distant events in the young Chronos' future, the probability of error increases. If the information is obtained from the older man the possibility of error is, at worst, lessened, and, at best, removed altogether (by means of electronic or other recording devices that may be examined for signs of tampering). This is due to the fact that the events lie in the old Chronos' past, and have, therefore, already been experienced by him. Consequently, he either has the knowledge of hindsight, or had -- and could have previously utilised -- the option of recording the events in question.

This graphic representation also indicates the nature of the relationship between the time traveller and his future. The personal time line that is shown existing between the younger and the older Chronos is a memory for the latter after he has made the journeys because it lies in his past, but it cannot be personally known by the pre-travelling man because it lies in his future, despite the fact that the personal time line does exist in a very real sense for both stages. The objective status of the personal time line for the younger of the two stages is a direct

consequence of its relation to the older Chronos. This is because the past-directed identity relation is a matter of fact for the older Chronos, and it is proof of the existence of the future-directed identity relation -- and therefore the personal world line -- of the younger stage. This argument is prevented from becoming circular by the fact that the substantial nature of the personal world line of the young Chronos is dependent upon that of the older man. The younger man cannot claim knowledge with regard to his understanding of the identity relation between himself and his future person-stage, except inasmuch as that claim is based on the actual knowledge possessed by the older Chronos that has been imparted to his younger self. The initial verification of the identity relation can only be established from the perspective of the older man.

The above further indicates an association between identity and freedom of will or, since the case will hold for any time travelling object regardless of whether or not it can be said to have a will, between identity and liberty. While the question of the traveller's freedom of will in general terms will be examined in more detail in Chapter 4, this aspect -- pertaining, as it does, specifically to identity -- can be examined briefly here.

Under normal circumstances (i.e. when not time travelling into the past) human beings are only prepared to acknowledge identity relations with individuals or person-stages who were previously existent (in terms of both the

personal and the external time frames). I might claim an identity relation with the person who was sitting here typing a letter this morning, or with the person who travelled to Durham University for the first time in 1984 from Sussex, and studied philosophy there, but it is doubtful whether I would make a similar identity claim with the person who could be sitting here later tonight, or the person who might one day live in another country. Indeed, even the words employed help to reinforce that hesitancy -- 'could be' and 'might'. What justification is there for the reluctance to commit ourselves that has been expressed above?

The problem appears to originate in questions of future personal liberty. A claim to an identity relation with a person who experienced an event in the past can be made with confidence because either the person making the claim can recall being the subject of, or connected with, the event in question, or they have been informed by trustworthy sources that this is the case, and that testimony conforms to the facts as they have been presented from a variety of sources. More importantly, however, nothing can happen in the future to alter the truth of such a claim (appeals to backward causation will be examined in Chapter 5). The past appears permanent and binding in a way the future does not (although the hypothesis has yet to be verified as anything more than an intuitive position in this thesis: see Chapters 4 and 5). It is common for human beings to refrain from affirming an



identity relation with a person experiencing a future event, because the necessary information regarding the experience is not available at the moment of the claim, and consequently the claimant can guarantee neither the occurrence of the event, nor their presence at that juncture.

If an identity claim towards the future could be made with the same assurance as that common to such claims to the past, it would indicate a lack of freedom on the part of the person making the claim. Yet, when a time traveller meets his/her future self, that is precisely what happens. If it could be proved, beyond doubt, that the person with whom one is speaking is a future stage in one's personal world line, then, with that proof, would come the apparent denial of one's freedom to change the future that led to that later stage. This is because, if it were possible to change it, the identity relation would not exist. From this it follows that, given the immutable nature of the past in one possible world relative to any temporal position -- even if the position is that of someone (Chronos) who comes from the future relative to the individual making the claim (Chronos' earlier person stage) -- every positive assertion of identity is also an acknowledgement that it is not within the power of the person concerned to change the relationship because it exists in the past personal world line of the traveller's older, and already existing, self. However, the extent to which the time traveller's freedom of will is

compromised by the identity relationship is further complicated by the association with the relationship between knowledge and liberty, and as such is part of a much wider problem requiring a more detailed analysis than that which can be provided in this chapter. Consequently, further study will be reserved until Chapter 4.

At this juncture a distinction between what is, in fact, the case (ontological), and the way in which people utilise terminology as an expression of understanding (epistemological) must be considered. The fact that people do not, in general, use terms of identity towards the future¹ does not prove that such relations do not exist, and through the analysis of time travel this fact may be highlighted. If an individual is, as a matter of fact, going to experience some event in the future, then that person can make an identity claim in advance with the person who will experience that event (present to future), just as much as the person at the time of the event will be able to claim identity with the person in the past relative to that point (present to past). Thus, once an identity relation has been established, it runs both ways. However, if an individual makes an identity claim towards the future (for example, X is identical with the person who will wake up in X's bed tomorrow with the looks and memories of X) he is not thereby guaranteeing the events that will lead to the particular

1. Promises such as 'I will meet you here tomorrow' do contain implicit identity assumptions, but an analysis of such phrases would reveal the same counterfactual requirements as I have listed below.

person's state of existence. At best, any such claims will be based on an (in theory) unlimited selection of counterfactual assumptions. For example, I might claim identity with a person who will be working at this computer tomorrow in the following manner:

If my computer is not stolen in the interim, then the person sitting at this machine tomorrow will be identical with the person writing this now; or

If no one other than myself enters this room and sits at my computer, then the person sitting at this machine tomorrow will be identical with the person writing this now; or

If I am not injured in the interim, or otherwise prevented from using my computer, then the person sitting at this machine tomorrow will be identical with the person writing this now.

The potentially infinite nature of the list leads to its being often reduced, when considered at all, to phrases such as 'God willing' or 'all things being equal'. Thus identity claims towards the future show a tentativeness rarely seen in claims towards the past.

When, in due course, there comes the need to verify the status of persons or objects which, it is claimed, hold an identity relation, if it is then discovered that no such appropriate relation exists, it is not that the relation did and then did not hold, it is simply that it did not exist at the moment of the initial claim. Rather, a prediction was being made that subsequently proved incorrect. On the other

hand, if such a claim is made and subsequently fulfilled, it is not the case that the claimant confidently stated future events as present fact. Rather, a claim was made that could have been right or wrong and was, in fact, proved correct. If information revealed by a time traveller from the future is added to the above examples, all that is discovered are the details of an incident that *has already occurred* from the perspective of the time traveller with whom the identity claim is being made. A preview of the future has been provided; yet the only difference between the status of the would-be time traveller before and after the meeting is that he has been provided with information regarding his immediate future rather than having to depend on educated guess-work. There has been no effect on the status of the individual in terms of his identity relation with the person from the future. Thus, although epistemological claims regarding identity are invariably in the direction of present to past, from an ontological point of view, in a world in which time travel into the past is possible -- and consequently a world in which the future and its contents must, in some sense, exist -- identity relations should be regarded as flowing both ways, thereby dissolving the problem posed earlier (specifically in scenario 2) of how an individual can not only make an identity claim with a person of whom he has no memories whatsoever -- amnesiacs are in the same position -- but also make an identity claim with a person of whom he can have no memories, since a memory, by

definition, must be of an event that occurred in the personal past of the individual reporting the memory. While, in scenario 2, the claimant cannot maintain that he has knowledge regarding the identity relation, the high probability that such a relation does exist -- which would be verifiable from the perspective of the claimant at some point in the future relative to the personal temporal reference frame -- is sufficient to justify the appropriate claims being made in advance. Once again, a full examination of this problem involves considerations regarding the association between knowledge and freewill, but these will be discussed in Chapter 4.

To return attention to a more detailed analysis of the illustrations, it can be seen in Fig 3.1 that there are, at first, a minimum of two people. Their world lines overlap across an interval of external time, thereby allowing them to talk to one another, but they otherwise appear unconnected. It should be noted that A's time line extends backwards to the moment of his birth, as well as forwards to the moment of the meeting, whereas B -- the older of the two parties -- has no history prior to his arrival in the year of the meeting, and seems to have been spontaneously created with the looks and memories of a man of fifty. Herein lies a clue to the identity relation that is fully revealed if the overlay is added showing the whole of Chronos' personal time line. After the meeting, the younger Chronos continues to live a normal (i.e. he is not time travelling) daily

existence until he reaches a moment at which he uses a time machine to travel backwards relative to the external time frame (the Y axis). Yet despite this temporal relocation, Chronos continues to age in the normal manner relative to the personal time frame, in keeping with the requirements of the popular interpretation outlined in the Introduction. He finishes his journey in the year in which his younger self is considering building a time machine at the age of twenty-five. From the conversation with his younger self arises the situation of two stages -- misleadingly termed 'copies' -- of the same man, one aged twenty-five and the other aged fifty, existing at the same external time and in close physical proximity to one another.

Fig. 3.2 also represents the appearance of two apparently unconnected people, but in this instance there has been added the problem that an identity claim has been made by A (the younger Chronos) without even the benefit of a meeting with the man with whom the claim has been made. Chronos has taken the information presented to him and, from that information, has concluded that the person in the past bears too great a mental and physical similarity for it to be merely coincidence. He could be wrong, for he is speaking of an event that, if it occurs at all, will occur in his personal future -- namely, the event at which he climbs into the time machine and operates the switch to travel into the past. He cannot claim knowledge regarding his future actions as such, but can only maintain that there is strong evidence

to support the contention that this is what he will do. But if the overlay is now added it becomes apparent that the identity relation is a fact of B's past, even if it is only a future possibility from A's point of view. Therefore it can be concluded that an identity relation exists between A and B, even though B alone is in a position to prove that relation by his memories, recordings, and so forth.

But if A and B are, in fact, one and the same person, with what justification is the term 'they' applied, and in what way are 'they' different? The problem becomes more acute in Fig. 3.3, where there appear to be six world lines apparently unconnected to each other in external time. The addition of the overlay again shows the relation between them, and so resolves the problem of the term 'they'. The appearance of multiples is a consequence of a temporal perspective that is centred solely on the external time frame. Once the personal reference frame is also taken into consideration the illusion disappears. However, this resolution is offset by the appearance of a new problem. In each case so far analysed, the two persons claiming identity have appeared to be physically different -- one is ten, twenty, or more years older than the other -- but in Fig. 3.3 there appear to be six men who are indistinguishable. Yet something must distinguish them, for otherwise, through the identity of indiscernibles, there would not be six materially distinguishable male individuals, but only one. What is the feature separating A, B, C, D, E, and F that

cannot be discovered by the scientific examination of each stage of Chronos?

This problem has been considered by David Lewis in his paper, 'The Paradoxes of Time Travel'. He suggests that whereas it would not be quite accurate to say that the whole of the time traveller is existent in two places at the same time, what is true is that:

...he, unlike the rest of us, has two different complete stages located at the same time at different places.

Lewis, 1986, p. 72².

Here Lewis is appealing to an identity criterion that uses a system of 'person-stages'. According to him, the identity of an individual does not reside in some enduring and unchanging physical or mental entity but in the causal continuity and connectedness, with respect to personal time, between individual temporal stages of a person's life. Lewis defines continuity as

the existence of step-by-step paths from here to there, with extremely strong local connectedness

2. Although I name Lewis as the originator, he is responding to Parfit's argument (see Parfit, 1971). Lewis adapts Parfit's original thesis in order that the two notions that Parfit claims are contradictory -- (1) that 'what matters is mental connectedness and continuity between my present mental state and other mental states that will succeed it in the future' and (2) that 'what matters is identity between myself, existing now, and myself, still existing in the future' (see Lewis, Survival and Identity in Rorty, 1976, p. 18) -- can complement each other. Otherwise, as Lewis says, it would be the case that 'what matters in survival according to one answer is present while what matters in survival according to the other is lacking.' Both must be the case in time travel.

from each step to the next.

Lewis, 1976, p. 18.

He defines connectedness as

direct relations of similarity and causal dependence between my present mental state and each of its successors.

Ibid.

The time traveller's existence, as shown by his personal world line, is divided into individual temporal parts or stages that are causally connected in such a way as to preserve the same sort of causal continuity that connects the person-stages of all beings who are not time travellers³. The duration of each person-stage is variable, the maximum length being one life-time; otherwise the length of a person-stage depends on the circumstances. It may be a week, a day, a year, an hour, or twenty years. Deciding factors for the moments of division may be appearance, age, particular point of view held, end of an experience or the beginning of a new one, and changes in behaviour patterns. Problems with defining a minimal duration period for a person- or object-stage might be correlated with the nature of time itself. If time is dense, no specifiable minimal stage exists; if time is discrete, the duration of the most

3. A similar proposal is put forward by Douglas Ehring in 'Personal Identity and Time Travel'; he defines a 'P-relation' as 'at least one causal chain of purely physical events between Jones-34 and Jones-4' (Ehring, 1987, p. 430). As shall be seen later, I do not endorse the 'purely physical' causal chain alone.

minimal stage could be as long as a discrete period of time. W.H. Newton-Smith argues that neither of these interpretations of the structure of time is entirely unproblematic: if time is dense, its continuous nature is lost, and yet that is an aspect whose existence is amply supported by empirical evidence; if time is discrete, there would have to be extensionless periods between the discrete particles -- a concept that appears inherently contradictory. Lewis overcomes this problem by claiming that a given person-stage is defined as being of sufficient duration to permit some person-related event. At the very least such an event would require a human thought, and that cannot take up an infinitely small period of time. This does not accommodate for the problem of defining the nature of object-stages for inanimate and/or non-sentient beings, but that problem will be considered later, and then only in so far as it concerns a specific example. An in-depth analysis is not necessary because the nature of time's structure does not affect the conclusions of this thesis, which apply regardless of the temporal interpretation employed (see Newton-Smith, 1984, pp. 112-126). It is the system of identity uniting the person- or object-stages that is important, regardless of the length of duration of those stages.

According to Lewis, between each person-stage

there is not too much change altogether.

Plenty of traits and traces last a lifetime...[T]he connectedness and the continuity are not accidental. They are explicable; and further, they are explained by the fact that the properties of each stage depend causally on those of the stages just before in personal time, the dependence being such as tends to keep things the same.

Ibid., p. 72.

This further endorses the personal/external temporal reference distinction made in the previous chapter. Whereas an examination of the time traveller in external time (the sole reference appealed to by those who would accuse time travel of inherent temporal contradiction) that shows a marked age gap between two externally temporally contiguous stages does not fulfil the identity criterion, an examination of the time traveller's personal world line does, since there are a series of causally connected person-stages that link the two occasions in the time traveller's life. Lewis further claims that

[w]hat unites the stages (or segments) of a time traveler is the same sort of mental, or mostly mental, continuity and connectedness that unites anyone else.

Ibid., p. 72.

What advantage does this system have for the time

traveller over other identity criteria propounded for humans or other beings or objects? Quite simply, it permits the situation outlined in Fig. 3.3 to obtain without entailing contradiction. There are those who argue that personal identity does not reside in the causal continuity and connectedness of person-stages, but rather in something indivisible and unchanging. Such a theory is advanced by E.J. Lowe in 'Substance and Selfhood' (1991). These criteria are, however, logically incompatible with the system of time travel presently being considered, because under no circumstances could either the traveller or his machine have more than one physical manifestation at any given moment relative to either reference frame without violating both criteria. Arguing from the opposite direction it follows that, if this system of time travel were ever to occur, the argument for an indivisible and unchanging basis for the time traveller's identity would be undermined. Furthermore - - unless it should be discovered that the traveller has a unique system of identity that enables his activities but prevents anyone or anything else from joining him -- it will also follow that identity criteria in general do not consist in unchanging psycho-physical entities. In contrast, success in any given attempt to relocate an individual temporally in either the future or the past relative to the moment of departure would not prove the accuracy of Lewis's particular identity criterion, but would merely indicate that his was closer to the actually existing state of affairs. Failure of

all attempts to time travel, however, could not be considered proof that identity consisted in a non-reductionist, separately existing entity view. It is possible that identity resides in a composite object, as in Parfit's suggestion (Parfit, 1984. Chapter 10), which combines the claim that

a person's existence just consists in the existence of a brain and body, and the occurrence of a series of interrelated physical and mental events

Parfit, 1984, p. 211.

with the claim that

A person is an entity that is distinct from a brain and body, and such a series of events.

Ibid.

The system of identity proposed in this chapter is a necessary, but not a sufficient, condition of successful time travel as presently defined.

In order to ensure that no logically possible system of time travel is overlooked, and so satisfy the criteria laid down for this thesis in the introduction, Lewis's system of identity will have to be expanded. To this end the unifying factor will be any causal continuity and connectedness with respect to personal time -- be it mental, physical, or even spiritual. This will enable attacks originating in claims to

reincarnation and cyclical universes⁴, as well as ensure that the identity criteria may be applied to inanimate objects such as tapes, letters, or even stones, any one of which could raise problems for time travel into the past. However, because thought experiments allow that it is possible for human identity to be preserved without the existence of a physical resemblance, or even a causal continuity and connectedness of physical parts regardless of their similarity, further discussion will concentrate on the problem of identity for a human time traveller.

Parfit terms this the 'widest view' definition of identity, and it is by no means universally accepted. The nature of the time traveller -- as a person who can exist in more than one physical location at the same temporal instant -- nevertheless demands a system of identity whose general structure fulfils the pattern outlined above. By the implementation of such an extreme stance I have given the time traveller the greatest possible freedom in his activities. If it should subsequently be demonstrated that, despite this, time travel, as so far defined, by its nature engenders logical contradictions that cannot be overcome without either a major restructuring of the definition or its abandonment, then it will follow that the argument provided against this system of time travel is of considerable strength.

By appealing to the causal continuity and connectedness

4. See S. Weir, 1988, pp. 203-209.

of person-stages with respect to the personal time frame, the question posed at the beginning of this section, regarding the means of differentiation for the six versions of Chronos encountered in Fig. 3.3, is resolved. Each is shown to be a different person-stage of the same man, connected by causal continuity and separated by time itself: not time at rest with respect to the external reference point, but time at rest with respect to the traveller. This would indicate that time is a genuine difference that must be taken into consideration, because the only distinguishing feature between Chronos as world line A and Chronos as world line B is temporal. Even were the temporal interval reduced to one nanosecond in order to ensure a physically identical state for both A and B -- avoiding the loss of hair or skin, or the accumulation of physical marks that is possible over a period as short as two seconds -- the difference of one nanosecond would still separate them. Without this difference of time, and the concomitant increased causal history it entails⁵, there would be no means of distinguishing versions A to F, and Chronos' attempt both to travel through time and to occupy more than one physical space at the same external temporal instant would be logically impossible. The status of increasing personal temporal and causal experience as both a necessary and a

5. This association of temporal and causal increase is a fact of the time traveller's activities as a being capable of accumulating experiences and acting upon them (or causing others to act upon them). It is not to be considered indicative of a reductionist position.

self-defeating facet of time travel under the present description will be considered in Chapter 5.

Highlighted in Fig. 3.4 is another aspect of time travel that is relevant to the problem of identity: the correlation of causally connected person-stages with respect to external time. The world lines on the first graph have been numbered in such a way as to show their temporal ordering relative to an external observer. Hence, the person watching the building of the pyramids comes first, followed by the birth and growth of the scientist until the moment of his departure in a time machine from the laboratory, and finally the old man who appears twenty-four hours later. However, the existence of any individual prior to the moment of his birth, as in this case, must be considered reason for further investigation, particularly if the first recording of the individual's existence made by an external observer shows the apparently spontaneous creation of a man with the mental and physical structure of a twenty-five year old.

Minimal analysis based on the previous examples reveals this thought experiment as structurally similar, on a fundamental level, to the examples already encountered. The existence of a time traveller prior to the time of his own birth, in external time (and in one possible world), is no more problematic than the discrepancy already noted between his personal age and that determined by external measurement from the moment of his birth to the moment in question. The overlay reveals the important fact that Chronos is behaving

perfectly naturally with respect to his personal time frame. Only if his personal world line were correlated with the external time frame under these circumstances would a genuinely anomalous situation arise: one in which Chronos would come into existence at a moment with respect to his personal world line that was *before* the moment of his birth relative to the same reference. In other words if identity is assumed, Chronos would exist before his existence began with respect to the same time frame.

This situation, while reminiscent of closed world lines, should not be confused with them at this stage⁶. A similar story-line under closed conditions would necessitate the traveller being an ancestor of himself, as well as his own descendant. Consequently, his existence at each stage in the loop could be explained in terms of every other stage, although the whole would remain unexplained. In Fig. 3.4, however, while there is no previously existing stage, relative to the external temporal reference, to explain the traveller's existence at that age and at that moment in time -- as in a closed world line -- he is neither his own ancestor nor his own descendant, having instead a normal parentage, as revealed when his world line is examined from the perspective of the personal temporal reference.

If the pattern of the traveller's existence with

6. In Chapter 5 I will argue that all time travelling journeys necessitate the generation of such world lines, even when they are to moments in the distant past. However, here the distinction between the general rule of time travel as later argued and the structure of this particular instance should be clearly delineated.

respect to the external reference were considered as though it represented the entire personal world line, the description would be neither that of a time traveller nor that of just one person. Fig. 3.5 illustrates this situation, with the personal reference now indicated on the main graph.

In all other respects this graph is identical to that of Fig. 3.4, but the absence of two temporal references has changed the way in which the information may be interpreted. It no longer represents three stages in the life of one person, but three different people, causally unconnected, whose world lines indicate bizarre histories.

Person A is spontaneously created near The Pyramids at the age of twenty. He is highly educated in a manner associated more with the twenty-first century AD than the twenty-sixth century BC. He claims that the object which appeared with him is a time machine that he used to travel from 2010 AD, and he also claims knowledge of the future. After a forty-year stay in Egypt, the man steps into his machine and throws the lever. He is instantly vaporised as a result.

Person B is born under unexceptional circumstances, and lives a normal life until the age of twenty, at which point he enters something that he claims is a time machine and is vaporised.

Person C is spontaneously created at the age of sixty, claiming memories of Egypt at the time of the Old Kingdom and of a young man who had disappeared the day before with whom he also claims an identity relation. He leads a relatively normal existence, until his death of old age thirty years later.

The above examples indicate that a claim which purports to prove the existence of time travelling activities by an individual must be supported by a rigorous system of identity in order that it may be effectively upheld: a system that appeals to causal continuity and connectedness between person-stages within a time frame at rest with respect to the person or object travelling. Without such an identity criterion, all the above examples might be relegated to that category of experiences termed examples of (fantastic) 'coincidence'.

If this system is to succeed in fulfilling all the requirements laid down at the beginning of this chapter, however, it is now necessary to examine whether or not it can distinguish between time travel as presently defined, and alternatives which, while perhaps acceptable within their own boundaries, are considered in some manner unsatisfactory or 'cheating' by proponents of the popular system. It is worth noting that although coincidences of the type listed above are presently considered highly improbable, were this system of time travel to become a

reality such situations would become common; this indicates a need either to revise our understanding of the physical realm, if we do not claim an identity relation, or to acknowledge the existence of time travel as defined, if we do claim such a relation.

Section 3

Weingard and Putnam Into the Future

In his article entitled "On Travelling Backwards in Time", Robert Weingard discusses Hilary Putnam's article "It Ain't Necessarily So". There, Putnam argued that time travel was a 'conceptual possibility' by providing a description of a traveller's activities that included world lines and time at rest with respect to frames of temporal reference -- a system commensurate with that presently under examination. In Putnam's example, the following Minkowski-style space-time diagram was employed (see Fig. 3.6) to describe the behaviour of a time traveller called Oscar. The line numbered 1 is the potential time traveller. At time t_e at A he steps into the time machine which begins its journey into the past at time t_2 ; line 2 represents that journey. At t_1 , B the time traveller steps out of his machine to live a normal life once more; this last stage is represented by line 3.

Weingard agrees with Putnam's initial description, providing definitions of personal ('proper') and external ('the world line of the observer') time and so indirectly

helping to define the system of time travel to which he is referring.

[T]he t -axis in [Fig. 3.6] is the world line of the observer or his laboratory, say, while the world line of Oscar₂ and his machine is the time axis of a frame of reference which is at rest with respect to the time machine. Given this, if we now wish to suppose that Oscar has travelled back in time, we can say that although events at a occur after those at b , with respect to the observer's frame of reference, events at a occur before those at b in the time machine's proper time.

Weingard, 1973, p. 117.

Here, the ordering of events relative to the personal (proper) time frame, and the consequent description of Oscar's time travelling activities, are in keeping with Putnam's description and with that presently under examination. The disagreements between Weingard and Putnam emerge when an objector's interpretation of Putnam's original diagram is provided.

[T]he correct description of [the activities represented in Putnam's diagram] is that Oscar₁ lives normally until t_2 , when he collides with a strange system and both disappear. At t_1 , this strange system somehow was created along with a person who resembles

Oscar Smith₁ very closely. Therefore the arrow on segment 2 of the Oscar diagram should also point upwards to agree with the arrows on segments 1 and 3. If you do not describe the situation in this way you will be using language with a change in usage or meaning from the ordinary way of speaking, and then this would not show that time travel is a conceptual possibility because what we want, of course, is a case that can be described as 'time travel' in terms of our present concepts of time, travel, and change.

Ibid., p. 118 (my emphasis).

Putnam responds by charging the objector with the latter's complaint, saying that the objector's image involves

...a host of difficulties which make us doubt whether to speak in this way is to go on using language without any change of use or meaning.

Putnam, 1962, p. 668.

and it is on this point that Weingard, with some justification, disagrees. He interprets the objector's picture as the behaviour of a matter transmitter in combination with matter/anti-matter creation and annihilation. In this manner the whole can be made to read in a perfectly logical and scientifically acceptable way. It works because anti-matter can be reinterpreted as backward

time travelling matter⁷; however, this interpretation also raises a problem.

The objector wants a system "which can be described as 'time travel' in terms of our present concepts of time, travel, and change". The anti-matter interpretation is a method of describing the behaviour of particles that has occasionally been used as an example of backward time travel; but the response made by those who reject the possibility of time travel, as well as by those who support the popular image of that activity, is that those who support the anti-matter method are 'not talking about time travel'. This is not strictly true, and painfully echoes the unsatisfactory argument of Holt in the last chapter, but if an alternative explanation, such as anti-matter behaviour, can be interpreted as a scientifically defensible form of time travel, why not simply accept it? The reason is because although both the popular and the anti-matter systems have been termed instances of 'time travel', the latter differs too much, and in too many significant ways, from the system of time travel that the science-fiction writers and, ideally, even some scientists would like to see realised. Weingard claims that by using a system for the creation and annihilation of the Oscars (namely a modified anti-matter interpretation) he will

7. The behaviour of a positron can equally be described as being that of a time travelling electron. This is rooted in the so called PCT theory which demands that whenever *Parity* or *Charge* is reversed, the *Temporal* indicator must be granted a negative sign also. See *The Arrow of Time* (1990, pp. 139-141).

...fill in some details to Putnam's case of the three Oscars so that in this new case the objector's description is the correct one and Putnam's time-travel description is clearly ruled out.

Weingard, 1973, p. 119

This suggests that Weingard is using anti-matter as an alternative that is not to be understood as a form of time travel, but is instead to be regarded as a system that appears indistinguishable from what is popularly seen as 'genuine' time travel but which, in fact, is not. It is this claim that will now be challenged. I will show that there are significant and detectable differences between the two systems that reveal the anti-matter interpretation to be inadequate to the task of impersonating Putnam's original. The two interpretations will be shown to be different but not, thereby, mutually exclusive. Neither system, in itself, denies the possibility of the other.

In his argument Weingard uses the two concepts of anti-matter and matter transmitters (the latter are an equally popular science fiction device -- witness the 'transporters' used in the television series *Star Trek*) to create his alternative interpretation. Since the latter are an integral part of his anti-matter analysis, these will be analysed first. The objective is to examine, within a philosophical framework, why the alternative interpretation differs, in what way it differs, and why that difference is significant

enough to make some reject it as an example of 'genuine time travel'. Ultimately it is hoped that from this analysis a system will be developed that will reveal any subconscious, or even covert, use of those aspects peculiar to either the matter transmitter or the anti-matter interpretation that indicates a position opposed to that of the defined structure of the popular system. It is in this last that the relevance to the present chapter will be revealed, because the omitted elements can be arrived at through an analysis of the time traveller's identity relations in comparison to those of the transmitted and anti-matter beings when attempting to fulfil Putnam's description.

In order to represent Putnam's written description more accurately, an arrow of personal time -- that Putnam omits -- has been added to the world line of the time machine. Without this, the machine must be interpreted as being at rest with respect to the external time frame, a situation that would be more in keeping with Weingard's anti-matter interpretation than with the time machine of Putnam's example. Since Putnam makes no indication that the personal time frame of the time machine is any different to that of the traveller within it -- and if it should coincide with the external time frame the machine's capacity to transport objects of matter into the past would be further complicated (see Chapter 5) -- I believe my addition is justified. However, even if it were not, because it is the nature of the traveller's behaviour that is of primary concern to

Putnam and Weingard, it is only necessary that the traveller and the surrounding universe of matter be physically separated from the anti-matter machine during the journey, and that some suitable explanation be found for the machine's abilities. Since I believe Putnam's intentions would be best represented in the graph I have provided, I will not examine the problems of interaction in this chapter.

The first stage in Weingard's alternative interpretation employs what he terms a 'matter transmitter' resident in New York. This machine records all of a person's mental and physical make-up, and in the process destroys them (a similar scenario was employed by Derek Parfit in chapter 10 of his book, *Reasons and Persons*). It then sends its recorded information, via radio waves, to a receiver (situated in Paris) that subsequently creates the person from matter stored within it, using the information provided by the New York transmitter as a blueprint for the process. The result, as witnessed by an external observer, is illustrated in Fig. 3.7. Causal continuity and connectedness is preserved between the destruction of the person in New York and his subsequent creation in Paris by the information being transmitted via radio waves. Therefore, a line connecting these two points on the personal time overlay is appropriate. Within the framework of science fiction such matter transmitters are common-place, but this fact does not resolve those problems of identity associated with them.

Weingard claims that

[i]f, for example, a person steps into one such transmitter in New York which then beams a directed radio signal to another one in Paris, the being that then steps out of the Paris transmitter would, I think, be naturally described as the person who stepped into the New York machine and not just a copy of that person.

Weingard, 1973, p. 119.

This is an assumption that requires some justification, however, which Weingard does not offer, although he does provide a possible objection that highlights the potential problems of such a system. He suggests that the signal from the New York transmitter might be picked up by receivers in other cities as well as Paris, resulting in more than one traveller being reassembled as a result of the initial transmission. He further claims that, since nothing could distinguish these beings one from another, and it is not possible that all of them could be the person who stepped into the transmitter in New York, therefore none of them is. Again, this argument is neither expanded nor supported, and consequently undermines the development of Weingard's later arguments⁸. Ignoring these problems, he adds a further qualification to his system.

⁸. Parfit would allow this as an example of survival (a many-1 relation) but not identity (a 1-1 relation).

We need to further imagine that once a person's structure is recorded in the memory of the transmitter, we can affect that memory and vary the structure recorded there.

Ibid., p. 120.

The purpose of this is to accommodate for the ageing of the time traveller during his journey within the machine. From this it is clear that Weingard does not support the concept of *instantaneous* temporal movement. It is necessary that the transmitted traveller age in order that he may mimic more closely the time traveller of Putnam's descriptions who, upon his exit from the machine at t_1 , B , has all the memories of a person who had existed from t_1 , A to t_2 , A and then travelled back in time to t_1 , B . An examination based on these aspects of Weingard's theory alone can already highlight differences between the genuine time traveller and the transmitted person, but first it is necessary to resolve a problem in Weingard's description.

Throughout his discussion, Weingard refers to the 'matter transmitter', yet his own description of the machine belies this title. He writes

When an object is placed in it, the machine analyzes the object's molecular and atomic structure and stores this information in its electronic memory. In the course of the analysis, the object is decomposed into a pile of its basic elements in an uncombined

state. It then transmits this information by radio waves to another matter transmitter which, on the basis of the received information, reconstructs the original object out of supplies of basic elements which it contains for this purpose.

Ibid., p. 119.

The machine is thus shown to be a transmitter of information rather than matter. Consequently there is one obvious sense in which it differs from the time travelling Oscar, in that whereas the latter is free to travel to wherever and whenever he chooses (problems associated with freewill and/or causality will be laid aside at this stage) the transmitted person is constrained by the need for a receiver at the space-time in which he wishes to be reconstructed. This advantage may be overcome if Oscar is subjected to similar methods and constraints, and in this manner both systems can be reduced in complexity to the one, important, distinguishing feature. The physical intricacies of trying to preserve a signal intact in all its complexity across temporal, as well as spatial, intervals will therefore be ignored. The only difference between the time machine transmitter and Weingard's transmitter is that one can alter its occupant's temporal, as well as his spatial, position: both will require transmitters and receivers in order to travel, and both will be transmitted as information to be reconstructed at the intended place of arrival.

Using Weingard's own example of a problem with his machine, it can be shown that his traveller could perform a feat of which Oscar -- in his capacity as a time traveller alone, and not in combination with those powers acquired as a consequence of the method of transportation -- is incapable, namely appearing in several different places, not just at the same moment relative to the external time frame -- as Weingard has already suggested -- but also at the same instant relative to the personal time frame. Figs 3.8 and 3.9 represent this activity as performed by the time traveller and transmitted traveller respectively. The difference between the two is not immediately apparent in the external time frame, but it becomes acute when the causal ordering of the events in each example is viewed from the perspective of the travellers themselves, i.e. the personal time frame. While the personal time overlay of Fig. 3.9 reveals straightforward connections between the person in New York and each of his later stages appearing in Moscow, Paris and Berlin, the same does not hold true of Fig. 3.8. In the latter, each stage is connected either directly or transitively to all those preceding and succeeding it by means of a series of person-stages causally connected and continuous with respect to the personal time frame. In Fig. 3.9, in order to preserve the appearance of temporal movement, the travellers' information would have to be transmitted at the same moment from New York to all the receivers, but if that were so there would exist no direct

identity relation as previously defined between the persons arriving in Moscow, Paris, and Berlin. This raises some interesting consequences.

It is possible to imagine an alleged time traveller who appears in Paris, steps out of the machine in order to prove his arrival, and is then killed by a freak accident. Simultaneously another traveller, with no knowledge of the accident, appears in Moscow. While some form of causal continuity and connectedness would be preserved with the New York transmitter, it is clear that no such relationship would exist between those at the Moscow and Paris receivers, except transitively via the earlier causal stage in New York. On the other hand, in order to create the same effect as his counterpart who is not time travelling, the genuine time traveller would have to be transmitted from New York to Paris and then, should Paris prove uneventful, be transmitted backwards in time and across space to appear at the same moment in Moscow and then, after a further journey in space and time, in Berlin. In this way he would appear in several cities at the same moment relative to the external time frame. Each reconstituted stage, however, would be slightly older than the one before, and would retain memories of the events that had occurred to each previous stage. Should any one be injured or destroyed, later stages would either bear witness to that injury, or not exist at all. No later person-stage than that at which he was destroyed could exist, because that would generate a

contradiction.

Even if Weingard's artificial ageing were introduced, the problem would not be resolved. The older version in Moscow would still be unaware of the accident that had befallen his counterpart in Paris until he was informed of the same. This is because there would exist no direct causal continuity and connectedness, with respect to the personal time frame, between the stage in Paris and that in Moscow. The Moscow stage would therefore appear blithely unaware of his incongruous existence, claiming memories of an entirely successful reception at his 'previous' port of call. Without knowledge in advance of the outcome of all the intended journeys, the only way by which this problem might be overcome is if each stage could be transmitted, successfully survive its reconstruction and emergence, re-enter the machine, then be transmitted to the next location, and so forth. Then, however, the illusion of time travel would be removed and pure spatial movement would remain.

Under this description, the time traveller himself would be free to experience fission as his opponent does, but this would be in addition to his own abilities, and quite superfluous to his needs in this example. The time traveller can successfully perform the feat without fission, his opponent cannot, and this is because his opponent cannot travel backwards after each journey to make up the time used in the course of the experiment. Weingard's transmitter might be accepted as a means of future-directed temporal

relocation in keeping with Mellor's arguments outlined earlier if it were combined with a storage medium (see Introduction): the element of fission, however, remains controversial.

The very fact that Weingard's traveller must resort to fission if he is to reproduce the appearance of the time traveller's behaviour makes Weingard's 'solution' considerably more complex, and may, in some quarters, render it a more suspect explanation, both technically and philosophically, than that of time travel for the circumstances described. However, there remains one more component of Weingard's description that must be examined before any final opinion may be passed, and that is the use of anti-matter.

Section 4

Into the Past

So far, this chapter has been concerned with a comparison between a time machine and a misleadingly named 'matter transference' machine, in which the latter has not been expected to transfer information into the past. Yet backward temporal movement is a vital aspect of the time machine Weingard seeks to discredit. In fact, the limitation is recognised in Weingard's article, where only two small paragraphs are expended on the description I have challenged above. His main proposal involves an anti-matter based interpretation of Putnam's original example. This is

graphically represented in Fig. 3.10.

Line 1 represents a person waiting until time t_2 for what he thinks will be the arrival of a time machine. At time t_1 at point B, a matter transmitter creates two people. One of these two (represented by line 3) has all the physical and mental characteristics that would be exhibited by a person who had time travelled from point A at time t_2 to point B at time t_1 : he is older, and he has the appropriate memories. The other person created at B (represented by line 2) is identical to the first except that he is composed entirely of anti-matter. This person is created inside (and with) a so-called time machine, and behaves in a manner indistinguishable from the time travelling Oscar (in keeping with the theories of particle physics). At time t_1 at A Oscar steps into the machine, and at point t_2 he and his anti-matter double are destroyed together with the machine.

I will now attempt to show that, despite the scientific basis for his argument, Weingard's anti-matter description nevertheless fails to account for all the necessary aspects of a time machine. Consequently, it is not as 'philosophically unimpeachable' a description as he claims.

A comparison of Figs. 3.6 and 3.10, which represent Putnam's and Weingard's interpretations respectively, reveals that they are not identical. There is no causal continuity and connectedness with respect to personal time between lines 1 and 2 at time t_2 (marked *) in Fig. 3.10,

and this is a consequence of the problem raised earlier. Had these two not met, there is no reason why they would not continue to lead their own separate lives -- although the life-style of the anti-matter Oscar would appear strange to those not sharing his opposite nature, and would also require some method by which it might be preserved from an explosive interaction with any form of matter (not just his double). Furthermore, if they did continue to live separate lives, the matter Oscar represented in line 3 would not, and could not, preserve memories befitting his status as the last stage in a world line that began at t_1 , A^9 , and this in turn casts doubt on the appropriateness of the identity relation between lines 2 and 3 at t_1 , B . In fact, the only relation between these two would be the fact of their mutual generation at the same space-time and their physical resemblance: their subsequent histories are quite independent. It is partly because of this that other differences emerge between the popular and the anti-matter interpretations of time travel.

If a matter/anti-matter partnership were created at time t_1 , the 'earlier-stage' anti-matter version could be destroyed at time t_2 (that being later than t_1 relative to the external time frame) without any effect on the activities of its 'later-stage' matter copy (see Fig. 3.11). Furthermore, even if on every occasion (for reasons as yet

9. Due to the fact that the anti-matter version's causal history would continue to grow after the supposed beginning (at t_2 , A) of his time travelling journey.

unexplained) that the anti-matter individual or object was destroyed independently of its counterpart, the matter version also ceased to exist at the same instant relative to the external time frame, the fact would remain that, until the moment of annihilation, there would have existed a matter version that appeared (under the time travelling interpretation) to be a later stage of an object or person that had been destroyed at an earlier stage in its personal time line (Fig. 3.12). Still more incomprehensible is the fact that, if the anti-matter version were destroyed at time t_2 , there would remain the anomalous existence of what appeared to be a causally later stage of that anti-matter being between times t_1 and t_2 (Fig 3.13). In contrast, once the time traveller is destroyed, no later person-stages (relative to the personal time frame) can exist, any more than an object that is not time travelling can continue to exist after its moment of total destruction. To resolve this problem, restrictions might be placed on the freedom to create anti-matter 'time-travellers'. Thus any attempt to create an anti-matter traveller would fail on those occasions when the being is destroyed before the moment of its combination with the person claiming to be a would-be time traveller, i.e. on those occasions when destruction occurs after t_1 , B and before (external time) t_2 , A on the Weingard diagram (Fig. 3.10). This not only poses extreme restrictions on the freedom of would-be time travellers (a subject that will be examined in the next chapter), but it

also generates a bilking experiment. This is because in order that the substance of the anti-matter being's initial existence can be determined, it must exist, for otherwise how is its non-existence as a consequence of events lying in the future relative to both the ordering of events from creation to destruction in the personal time frame (appearances to the contrary notwithstanding, see below) and the external time frame to be known? This is not a factor for the backward-moving time travelling object, because that comes from the future. While the non-existence at a pre-departure specified time and place in the external past (relative to the moment of departure) of a backward time travelling object might be interpreted as a warning that events will not turn out as anticipated -- because that event lies in the object's personal future -- it cannot affect the substance of the time travelling object's physical existence until that point is reached in its personal time line. From the above it may be seen that all the problems of the anti-matter interpretation stem from the fact that whereas the *appearance* is of an object coming from the future, the *fact* is that the moment of anti-matter creation is at the earliest moment of its existence relative to the external time line, and the moment of its annihilation is at the latest. Conversely, the creation of the time travelling object may lie at the latest moment of its existence relative to the external time line.

D.H. Mellor also rejects the anti-matter interpretation

as an example of time travel. He writes

we must distinguish sharply between reversing the temporal order of types of events and reversing the order of particular event tokens. e_1 , e'_1 and e''_1 are all tokens events of one type, namely a clock hand's passing a numeral '1', while e_2 , e'_2 and e''_2 are all of another type, namely hands passing a numeral '2'. What matters for backward time travel is that the temporal order of a pair of these tokens be reversed, i.e. that by the standards of the outside world their causal order be reversed. Of what types these tokens are is immaterial...It is irrelevant to time travel that clock hands normally go round clockwise and that electrons outnumber positrons. A positron is not an electron going backward in time, any more than an anti-clockwise clock is an ordinary clock time-travelling -- or, come to that, than an ordinary clock is a time travelling anti-clockwise clock.

Mellor, 1981, p. 173 (my emphasis).

The difference between the anti-matter and popular interpretations, from which may be derived all the problems cited above, may be found in the definition of the latter given in the Introduction. There the time travelling object or being was defined as carrying information from the future relative to the moment of arrival. At its most basic, that information is only enough to communicate its futuristic

origins and so prove its characteristic ability. Scars, marks, or a failure to arrive at a designated time and place after the necessary arrangements have been made, all communicate information about the future, even though, in the last case, it is merely that something will go wrong. Mellor use this point to show that time travel is not synonymous with backward causation -- although he argues that it does, ultimately, lead to it. He highlights the difference of causal and temporal orderings inside and outside a time travelling machine, and asks why these orderings should be opposed. He writes

I get the answer to this question from the indubitable proposition that to arrive is to have travelled. If Dr Who's Tardis sets off in 1984 and arrives later in 1884, it has travelled back in time. Dr Who set off in 1984 before he arrived in 1884 because his nineteenth-century appearance is affected by his twentieth-century departure, not vice versa. His wearing his scarf as he emerges from the time machine is an effect, not a cause, of his putting it on as he set off, as is his 1884 recollection of having done so.

Ibid., p. 174.

The anti-matter being brings nothing from the future: it either loses tell-tale signs as it journeys backwards, so that there is no moment -- relative to the external time frame -- at which it has information inappropriate to the

period; or it simply never has that information because it has not come from the future, the object merely giving the appearance of having done so. The choice of explanation depends on the beliefs of the person speaking, but, whichever is cited, it is the lack of causal continuity and connectedness with respect to a personal time frame that is always positive for the traveller that is the underlying cause of the problem¹⁰. The various stages of the anti-matter being lack an identity relation, as defined, with an object that *has come from the future* relative to the moment of examination, and the physical and logical inability to provide that evidence is a direct consequence. The success of the identity analysis is, in turn, dependent on the existence of a personal/external time frame distinction that is absent in the anti-matter interpretation.

It is worth noting that without the above distinction and the identity relation that depends on it, the anti-matter being must be assumed to be exhibiting an example of backward causation whenever it is interpreted as time travelling into the past. Since backward causation is a feature often attributed to time travel into the past, a

10. Mellor does not refer to temporal passage inside the time machine, referring instead to the causal passage within the machine in contrast to the temporal and causal passage outside it during backward time travel. This appears to support Lewis's reluctance to refer to the passage of time inside the machine as time -- although he admits it plays the same part in the traveller's life as time. I note the difference of opinion but, since there appears to be no means of discerning a difference between time inside and outside the machine (if it was discovered that the entire universe as we know it was time travelling with respect to another universe would we claim that what we experience was not 'genuine' time?) I feel that 'time' is a term that may be justifiably applied to the duration experienced by the traveller inside his machine.

more detailed examination of the subject will be provided in Chapter 5 (Causation). There, its relevance (and the relevance of arguments placed against it) to the present system will be examined. Consequently, further discussion will be reserved until then.

Can the above example be considered proof of the effectiveness of the specified identity criteria as a means of exposing alternative interpretations that do not fulfil the requirements of the time travel system under examination? Inasmuch as it has revealed something about the needs of the popular formulation of time travel, the answer is 'Yes', because any claim to time travel in which information regarding future events is transmitted into the past must be based on an identifiable discrepancy between a time travelling object's personal experience of time, and that of an ideal observer at rest with respect to the external time frame throughout the period of the claim (as shown in the Introduction and Chapter 2). And in order that the discrepancy may be appreciated as such it is necessary that the experience belong to one span of existence, causally connected and continuous with respect to the personal temporal reference, for which the moment of creation is always the earliest moment of personal experience, and the moment of destruction the latest, regardless of the positions of these moments relative to the external time frame. In other words, the discrepancy, in combination with a system of identity that limits the

experience to one object relative to which the causal flow is always positive, both defines time travel and, as a consequence, identifies counterfeit claims.

Section 5

Other Applications and Some Problems

The last two sections were concerned with a study of how identity relations could be used to distinguish between genuine instances of time travel and imitations that appear convincing on a superficial level. In what way might the conclusions drawn from this study aid an understanding of personal identity relations on a wider scale?

According to Derek Parfit, the simplest view of identity relations is of the following form:

[t]he criterion of identity over time -- or what this identity involves -- is the physical continuity, over time, of my brain and body.

Parfit, 1984, p. 204.

Yet, by the application of a thought experiment that affected our use of the external temporal reference, it was shown that day-to-day appeals to the causal continuity and connectedness of persons with respect to that reference are only of value inasmuch as it does not differ, under normal circumstances, from that of personal time, and it is this reference that is important to the identity relation. The passage of time for the individual is therefore to be

considered a higher priority than the passage of time *per se*.

The importance of the nature of the causal relationship from the perspective of the stages being related cannot be over-emphasised. The remainder of this chapter will be dedicated to an attempt to highlight the value of this perspective, and, in so doing, apply the conclusions of this chapter to other identity problems not directly related to time travel. However, this study will also reveal further problems with the causal continuity and connectedness criteria. While efforts will be made to resolve these problems it will be seen that although the system of identity suggested is a necessary feature of successful time travel into the past, it includes features that may, in some minds, detract from its claim to resolve the problem of identity for the time traveller.

In his article 'Survival and Trivial Facts' (*Analysis*, 1987) Douglas Ehring attacks, by means of thought experiments, Parfit's claim that what really matters is survival (not identity¹¹) and what matters for survival is his 'Relation-R'. Parfit defines Relation-R as

*psychological connectedness and/or continuity
with the right kind of cause...The right kind of cause*

11. Identity is always a 1-1 relation; survival may be a 1-many or even a many-1 relation. This point, and the consequences arising from it, will be returned to later in this chapter.

could be any cause.

Parfit, 1984, p. 215.

Ehring gives the following argument:

Case 1. Imagine it is possible to encode information regarding a person's personality traits and memories onto tape. After the destruction of the original body (A), the information is in some manner passed, in its entirety, into a new body (B). The outcome, claims Ehring, would satisfy Parfit's Relation-R and so should be considered by A to be as good as ordinary survival.

Case 2. Imagine that, after the original person (A) has been destroyed, the tape holding the information is dropped onto the encoding machine and damaged beyond repair. However, the striking of the machine by the tape causes it to malfunction, creating a tape that is totally identical to the one that had been damaged. This created tape is not a copy, as Ehring is at pains to emphasise, but merely the result of an unlikely coincidence. The information on this new tape is then passed into another body (B), who now has all the memories of person A. Here also there is an R-Relation, according to Ehring, because Parfit allowed any causal route from A's experiences to B's apparent memories.

Case 3. The tape is destroyed and a totally unrelated

malfunction of the encoding machine subsequently causes a tape to be manufactured that is an exact duplicate of the original, despite there being no causal link between tape A's destruction and tape B's production.

As Mark Siderits points out (Siderits, 1988, p. 30), the problem requiring resolution is not between cases 2 and 3, but between cases 1 and 2. A causal relation exists in case 1 that is not repeated in case 2: in the former, the nature and structure of the information on tape A directly causes the structure of the information on tape B; in the latter case no such direct relationship exists and

the falling of a blank tape might have caused the second encoder to produce a tape capable of duplicating all of A's brain states....[I]t is not, as Ehring claims, the move from (2) to (3), but rather the move from (1) to (2) that eliminates the relevant causal dependence...And [Parfit] can maintain that the difference between (1), where R does obtain, and (2) and (3), where R does not obtain, is deep. It is the difference between A's psychological states causing B's psychological states, and something else causing B's psychological states.

Siderits, 1988, p. 30.

Consequently, no further consideration will be given to the final stage of the thought experiment.

Ehring's argument hinges on a conflict between the intuitive and logical responses to each scenario. Intuition demands that person A reject the series of events in case two as an unacceptable means of survival; logic points out the undoubted causal relation existent between each stage which, in turn, seems to imply the presence of Parfit's Relation-R, established as intuitively and logically acceptable in the first scenario¹². The undermining of Parfit's Relation-R is dependent on Ehring forcing his antagonist to admit a preference for the intuitive response to the second scenario, thereby denying the importance of Relation-R to survival criteria. An analysis of the structure of Ehring's thought experiment to reveal why this preference arises would, therefore, be productive.

One response may be that while there does exist a causal relation between person A and person B, it is of 'the wrong sort'. But this leads to the inevitable question: what would constitute 'the right sort'? Rather than attempting a careful deconstruction stage by stage of Ehring's scenario, the application of the conclusions of this chapter can be invoked since they are independent of any outside influence, being, by their very nature, restricted to nothing more than the object claiming identity, and even divorced from frames of temporal reference with no direct influence on the object. In this example the objects between which an

12. There are those who would disagree with Ehring's assumptions regarding the first scenario, but in order for the argument to proceed it is necessary that a general agreement be assumed.

identity relation is said to obtain are not the tapes or, directly, the persons (although they are clearly affected in the long term), but the memories themselves. The question is whether or not the memories implanted into person B, that were encoded as a result of the accident described in case 2, can be considered not just identical in content (a fact that is not disputed), but so related to person A's memories as to make the subsequent implantation in B sufficient to enable B to claim that he is the mental heir to A, and so should be accorded the rights and privileges due to A, even though the body is different¹³.

Taken from the perspective of the memories themselves - - a study that requires that all external temporal proximity be ignored as potentially misleading -- there is a breakdown of the direct relations between the stage of existence represented by tape 1 and that represented by tape 2, and it is this breakdown that makes the identical content of tape B a matter of coincidence. A causal relation of 'the right sort' would require that it is the structure and content of the memories, and not the tape on which they are stored, that must determine the nature of the memories on tape B and, therefore, the memories in person B. The close external temporal proximity of the incidents can act as a smoke-screen, giving the illusion that Parfit's Relation-R exists when it does not. Once that time frame is ignored, the way

13. I am assuming the body is of the same sex. Clearly if this were not so, certain rights must be withdrawn, but this does not affect whether the memories in B's mind are those of A.

is easier to recognising that the relation is one of coincidence: any external time interval could have intervened between the annihilation of tape A and the creation of tape B, and the relation would have been the same.

It is, perhaps, worth remembering that in this instance the problem of defining object-stages can once again be raised (see Section 2). Specifically human-orientated thoughts or behaviour cannot be carried out while the person's psychological structure is encoded on inanimate tape. While a physical distinction between the existence of person A up to and including his encoding on tape and the existence of person B starting from and including the encoding on tape B can be drawn, in order to avoid any pre-judgement of the issue of identity it would be more appropriate if it were supposed that on every occasion when a person's psychological structure was physically relocated in its entirety¹⁴ to another place of storage -- be it on tape, computer, encoding machine, or whatever -- the period spent in that place of storage were considered another, separate stage. In this manner the problem of defining an object stage might be resolved, while the question of the existence of appropriate causal relations between the object-stages will remain to be determined in the manner outlined above. Yet that analysis may not be enough. What of

14. It will be assumed that the whole of a person's psychological make-up is present at any given person-stage, thereby obviating the need to examine the highly controversial and involved subject of matters of degree.

examples where there exists an even stronger causal dependence between the end (or destruction) of one stage and the beginning (or creation) of another?

In 'Personal Identity and Causality: Becoming Unglued' (*American Philosophical Quarterly*, 1987), Daniel Kolak and Raymond Martin provide an interesting counter-example to test the value of a purely causal analysis of identity relations, based on Parfit's Relation-R. The structure of their argument is paraphrased below.

Imagine a super-computer that creates mathematical object-configurations (MOCs) by a random manipulation of variables. These MOCs can be perfect descriptions of every detail in the make-up -- both physical and, where appropriate, psychological -- of any object or person who has, will, or might have existed. By this totally random method perfect descriptions are created of Socrates, Hitler, Florence Nightingale, the Eiffel Tower, blobs of matter, and Lenin's tomb. In addition blueprints are created for people and objects that have not been, and may never be, realised in this universe. In order to operate the machine, a person or object is placed in one side that is devoted to analysing (in the writer's example they suggest Robert Nozick). The computer creates an MOC of the object analysed that it stores, updating it moment to moment in order that it is, at all times, a perfect record of the analysed person or object. Simultaneously it begins randomly manufacturing MOCs

at an enormous rate. After a while it manufactures, quite by chance, a description that qualitatively matches that of the object or person being kept in storage. Once this occurs, the computer uses the blueprint to manufacture, out of new matter, an exact replica of the object in storage, and simultaneously destroys the original. As a result, it is the manufactured person or object that is retrieved from the machine after the experiment is ended.

The rejoinder to this example¹⁵ is that the replica does not *arise out of the original*: its generation is entirely spontaneous, and it is not a continuer of the object with which the relation is supposed to hold. Consequently there is no identity relation. This is akin to approaching the argument from the perspective of the object concerned. Furthermore, it is worth noting that although there is no doubt that the eventual manufacture of the replica and the destruction of the original are dependent on an exact match being obtained between the two, there is no logical reason why both replicas could not be permitted to leave the machine and co-exist in the outside world. Under such circumstances, would the causal relations between the two be sufficient to support a claim to survival (or identity)? Like the well-worn example of the ship of Theseus, while the original continued to exist it seems

15. By Nozick in an earlier attack: see Kolak and Martin, 1987, p. 343. The authors argue that the example is not so clear-cut as to admit Nozick's attack, but I do not find their argument convincing.

unlikely that the replica would be granted the status of heir to the original and/or identical with it: but the true test comes when the original no longer exists. In the absence of any closer relation one might be inclined to hold the replica to be the heir to the model on which it was based and, in human cases, morally responsible for acts committed by its model before the moment of the replica's creation, and this, in turn, suggests the assumption of an appropriate identity relation. Yet once the idea is put in this manner the situation appears absurd. How can a person be held responsible for something that he could not have committed because he had not been created?

Kolak and Martin argue that if one can accept an identity relation between a person before and after the use of a transmitter (or other 'transporter' device) there seems no logical reason why this MOC example cannot also be considered an example of survival and/or identity. Yet because the copy is manufactured spontaneously and accidentally the required causal continuity and connectedness from the perspective of the objects claiming identity is lacking. True, it was physically created because it matched that in the other side of the machine, but the reasons for its material construction are not the same as those for its mathematical creation. The latter is accidental and spontaneous, and since the MOC is the blueprint for the material person who finally emerges, that person's structure is a matter of accident, although the

fact of the material construction was dependent on a match being detected. Where true identity or survival exists, therefore, no aspect of the relation is accidental. Both Ehring's example and that of Kolak and Martin can be labelled examples of deviant (or wayward) causal chains. The intended result has been achieved in both examples, but the external appearance of the situation in each case -- and the assumption of relations based on that appearance -- differs markedly from the facts of the subsequent object's creation.

Here it may be worthwhile to analyse my use of 'identity' and 'survival'. In the above they have been regarded, to all intents and purposes, as interchangeable. This is because the primary distinction between survival and identity -- that the former is a many-one or one-many relation, and the latter is a one-one relation -- has not been a matter of concern. Regardless of whether there are many persons created as a result of the processes outlined above, or only one, the important aspect in each example has been to question whether the causal relation between the original and the subsequent object/s has been appropriate to either identity or survival. Despite the ingenuity of the counter-example, I do not believe Kolak and Martin succeed in proving that causal connectedness and continuity are insufficient to survival or identity. The previous discussion has, however, introduced the concept of deviant causal chains.

From a practical point of view, an analysis of the

causal conditions that obtain at the moment in question, to determine whether or not the end result was achieved by luck or design, would probably be more efficient than attempting to analyse the relations from the perspective of the objects concerned, although the result amounts to the same thing. In identity relations based on the causal continuity and connectedness of person-stages, a deviant causal link would be one that did not fulfil the appropriate relations from the perspective of the person- or object-stages concerned. Deviant causal chains are, of course, subject to further philosophical discussion¹⁶, but they are sufficiently well-known for their inclusion to be an important consideration when forming the identity criteria for the time traveller. Therefore, rather than undertaking the (technically more difficult) task of analysing all identity relations from the perspective of the person-stages, henceforth the traveller's identity relations may be defined as dependent on the existence of a causal continuity and connectedness of person-stages relative to the personal time frame (still a valid distinction during time travelling activities) provided no deviant causal relation is found to exist.

In reference to the survival/identity distinction, two more points may be raised. Parfit provides the following addition to his theory.

Our identity over time just involves (a)

16. See, for example, Michael H. Robins, 'Deviant Causal Chains and Non-Basic Action', 1984.

Relation-R -- psychological connectedness and/or psychological continuity, either with the normal cause or with any cause, provided (b) that there is no different person who is R-related to us as we once were.

Parfit, 1984, p. 216.

Present day-to-day experience certainly supports (b), and while it is true that the time traveller's understanding of the passage of external time differs from that of persons who are not time travelling, there is no reason why his physical structure should in any way be affected by that experience, and indeed, the popular concept holds that an understandable mental disorientation would be the only physical manifestation of a human traveller's temporal activities. The first stage in this definition of identity, as distinct from mere survival, has been shown to be too wide, and must, therefore, be fortified in the manner already described if it is to serve the purposes of the time traveller (or, arguably, anyone or anything else), but the second stage could be used to ensure that any criticisms based in multiple reproductions or fission would be effectively invalidated as being in violation of (b) above: the question is, is it really necessary? A thought experiment can help to determine the answer.

Imagine Chronos living a normal life until the moment when he begins his time travelling activities. His method of

transportation into the future employs a system similar to Weingard's transmitter described above, and through the course of one journey an accident occurs in which his information is simultaneously transmitted from New York to two independent receivers situated in Paris and Moscow, resulting in his being recreated at two spatial locations at the same moment relative to the personal time frame, i.e. fission. Being informed of the error, Chronoses 'A' and 'B' determine a way of recombining into one using the transmitters, with each centring their transmissions on the original cause of the error in New York. As a result, the being who finally emerges in New York has the memories of both the person called Chronos who existed as one individual up to the moment of fission, and the memories contained within 'A' and 'B' of Paris and Moscow.

It is difficult to see how such a situation as that described could arise, because the resulting person stepping out of the New York receiver would contain within his memory two conflicting accounts of the events of the last few days -- one of which may even record the death of that version. Furthermore, both memories would be of the same periods of personal time and would be equally valid. Yet it is not the mental or physical problems that are of immediate concern, but the identity relations between each stage.

The required identity relation is satisfied in the normal manner up to the moment of fission. At that moment each version stepping out of the receiver in Paris and

Moscow would have equal claim to a survival relation (the word identity is not applicable here, since that can only be applied to a 1-1 relation) with the person who stepped into the transmitter in New York, but not directly with each other. There is no direct causal continuity and connectedness between Chronos in Paris and Chronos in Moscow, except via the original in New York. Consequently, while both could, and should, be held responsible for acts committed by the person in New York before the moment of fission (relative to the personal time frame), without a direct identity relation lying in the past personal time line of one or other version, neither could be held responsible for an act committed by the other subsequent to the moment of fission. Indeed, they could engage in actions aimed at the destruction of one or other of them without any detrimental consequence -- rooted in their mutual genesis -- being experienced by the surviving individual. However, once fusion had taken place the version in New York would be equally a product of both previous persons because there would exist the same relation between him and the persons in Paris and Moscow. Once again, because this is a many-one relation it represents survival as opposed to identity, but because the relation in question, if it exists at all, is also symmetrical (see above, Section 3) the persons in Paris and Moscow could both claim a direct causal relation (i.e. non-deviant) with the subsequent (in personal time) person emerging in New York, were they aware of his existence as a

result of their time travelling activities. Indeed, they could claim the relation without that knowledge (although this is not usual), because whether or not they are aware of the successful outcome of attempted fusion will not alter the fact, if it should occur, of his existence in their future.

In this way the identity method outlined in this chapter provides a system by which fission and fusion might be detected, as well as a method for determining the appropriate relations between those persons created as a result of such activity. This factor has been noted by Elliot (1991) where he writes

[w]hile Parfit thinks that CCR [the causal continuity requirement] is necessary both for personal identity and survival, CCR might nevertheless be thought to underwrite somehow the distinction between personal identity and survival. For example, where causal pathways branch, linking more than one psychologically similar person to an earlier person, we have survival. Where the causal pathway is non-branching we have identity.

Elliot, 1991, p. 62.

From the psychological perspective, the difference might be determined as follows: if all the events experienced by each version can be traced back using the identity relation without mutually contradictory assertions being made about

the same instant of personal time at any moment in that past history, the individual in question has not experienced fission. Should mutually contradictory assertions be made regarding events occurring at the same moment relative to the external time line, although at different points relative to the personal time frame (for example, experiencing an event that occurred before the person concerned was born, or experiencing an event in place A and simultaneously, though at a later or earlier stage relative to the personal time frame, experiencing an event in place B), time travel can be assumed to have taken place, the exact moment in personal time at which backward temporal movement occurred being revealed by an analysis of the stages at which these contradictory assertions began and ended. In contrast, should contradictory assertions be made about events occurring at the same moment relative to the personal time frame, fission will have taken place. Should further contradictions occur relative to the external time frame (for example, on the first day of his twentieth year, Chronos is in New York in the year 1999, and on the first day of his twentieth year, Chronos is in Moscow in the year 2036) time travel can also be said to have taken place as above.

The use of a system of causal continuity and connectedness between person-stages by non-deviant means is therefore shown to accommodate both time travel and -- physical, mental or theological conundrums notwithstanding -

- fission and fusion. This last may not be considered an attribute that lies in its favour, and some would doubtless argue the unacceptability of such a system on the grounds that fission and fusion are *a priori* impossible. What the above does show, though, is that in finding a system for a time traveller, other, perhaps unwanted, by-products may also be permitted. In order to negate this conclusion it would be necessary to assume that the contradictory nature of the memories relative to the personal time frame of the recombined person would prevent fusion. This does not, however, prevent fission. In order that the time traveller be in a position to communicate with previous and subsequent stages in his personal time line via time travel, as well as merely exist at two different spatial positions at the same moment relative to the external time frame, it is necessary that the identity criterion should unify without demanding indivisibility, and in this way fission is enabled. It is at this point that the value of Parfit's extra premise is revealed.

If identity, as opposed to mere survival, is deemed more important to the time traveller, questions over fission and fusion would no longer be applicable. Since neither fission nor fusion is a necessary logical feature of time travel as popularly defined, by restricting the relation between person-stages to one of identity, examples of ersatz time-travel that utilise these other methods might be revealed, and in this manner the most important aim of this

chapter -- to determine a system of identity that would distinguish time travel from its would-be imitators -- will be achieved.

Section 6

Conclusion

To what extent have the initial aims of this chapter been fulfilled? A system of identity has been outlined that is appropriate to time travel, and that can distinguish the genuine instances of that activity from mere appearances. The thought experiments in this chapter have also helped to reveal a symmetry of identity relations through time, indicating that references to the relation from present to past, although more common, have no more intrinsic value than those from present to future in a world in which time travel into the past is possible, a world in which every appearance of a time traveller at a moment anterior to that of his departure is proof of the existence of the future. The strength of present to past relations lies instead in the knowledge they are based on and our assumptions regarding the immutable nature of the past. This reveals a distinction between our understanding of identity relations (the epistemological view) and the relations themselves (the ontological view). From the further analysis of the causal system chosen, the irrelevance of external temporal proximity to matters of identity, except inasmuch as that temporal reference does not differ, under normal

circumstances, from the personal time frame, was revealed. From this aspect was highlighted the importance of the causal connections between person-stages from the perspective of the stages themselves, and this, in turn, was applied to other thought experiments that did not use time travel. The relation was shown to be equally applicable to such examples. While this is not surprising, because the causal continuity requirement was originally designed with a view to resolving problems that did not, generally, involve time travel, it does show that a system of identity that includes aspects appropriate to a time traveller remains commensurate with systems of identity proposed for persons or objects that are not time travelling -- a feature necessary if the time traveller is ever to halt in his journeys.

From the analyses of the examples from Ehring, Kolak and Martin the technically simpler but, nevertheless, philosophically debatable concept of deviant causal chains was introduced, replacing the need to analyse causal chains initially from the perspective of the objects concerned with the more general task of analysing all causal relations, and only examining relations from the more specific perspective when indications of causal deviancy are revealed. Finally, the inclusion of Parfit's qualifier, limiting the number of persons capable of holding the appropriate causal relation with a previous person-stage to one, ensured the exclusion of fission and fusion from time travelling examples,

although it was shown that there are methods of revealing whether or not these events had taken place, should the need arise¹⁷.

Many problems remain. Discussions on the nature of identity for persons -- regardless of whether or not they are also time travellers -- will continue, and there appears no means by which they may be resolved once and for all. The system outlined in this chapter is adequate for the present purposes of this thesis, however, and can be reconsidered should the need arise. It is therefore appropriate to move on to the next topic of discussion. To this end it should be recalled that earlier in this chapter the question of personal liberty was raised. When a time traveller visits an earlier person-stage -- either directly to communicate information or simply to watch -- the freedom of that earlier stage not to travel in time appears to have been violated, because the consequences of that future act are already being felt. The next chapter will be devoted to the study of this problem.

17. Once again, it must be emphasised that there is no logical reason why time travel should involve fission or fusion. In contrast, many ersatz models of time travel do demand these features.

Chapter 4

Freewill and Determinism

*The moving finger writes and having writ
Moves on. Nor all thy piety, nor wit
Shall lure it back to cancel half a line
Nor all thy tears wash out one word of it.*

Omar Khayyam, 1859, Stanza LI.

In the preceding chapter it was argued that problems arising from the association that exists between identity and responsibility are not as important, for the study of time travel, as those between identity and freedom of will or identity and liberty. The word 'liberty' would allow for the consideration of all time travelling objects, and not merely sentient beings capable of self will, but this chapter (like the thesis in general) will be primarily concerned with the problems as they arise when viewed from the perspective of a rational being, and

*...to every rational being possessed of a
will we must also lend the Idea of freedom as the only
one under which he can act...we cannot possibly
conceive of a reason as being consciously directed from
outside in regard to its judgements.*

Kant, *Groundwork of the Metaphysic of Morals*, A448.

Consequently I have deemed the word 'freewill' more appropriate to the circumstances.

The problems to be considered are those that pertain to the freedom of will of an individual travelling into the past in one possible world, i.e. a person who is in a position to affect his own recent or distant past. By 'recent' is meant any temporal instant lying in the past relative to the traveller's personal time line -- i.e., any moment that he could have experienced in his lifetime as a person who is not a time traveller; 'distant' is defined as any temporal instant lying in the past relative to the first occasion -- as recorded by the time traveller -- on which he uses a time machine, that is not contained within the first category.

Consideration will be given to the problem of the traveller's own knowledge of actions and events that lie in both the external past and the personal future of the traveller, with a view to determining whether or not he is 'consciously directed from outside in regard to his judgements'. In order that the examples -- in the form of thought experiments -- may be subjected to the most rigorous analysis, each will be approached from an incompatibilist standpoint, and then gradually modified as each successive test is failed. In this way it is hoped both that all the alternatives available to the potential time traveller will be considered, and that the analysis will be the clearest and most practical available for the problems being encountered.

What is the relation between identity and freedom of

will? In the next few pages a variety of thought experiments will be proposed in which it appears that Chronos' ability to think and act freely has been curtailed by his activities as a time traveller. However, it will become clear as the chapter progresses that the appearance, but not necessarily the fact, of causal determinism experienced by Chronos is a consequence of the existence of events at a moment that is previous (relative to the external time frame) to the moment at which the causes of that event were initiated; and these, in turn, lie in the traveller's personal -- as well as the external -- future. Thus the effects lie at a point relative to the external reference that is anterior to the moment at which the decision was made to journey to that point, whereas the causes lie in a moment posterior, in the traveller's personal experience, to the moment of decision. This difference between the location of events relative to the personal and external time frames is only possible because there is only one person involved. Thus it is the identity relation between the person in the future who is at an earlier person-stage, and the person in the past who is at a later one, that reveals the direction of cause and effect through personal time that creates the appearance of a causal violation when viewed from the external perspective. In simplified terms, this means that a person in the year 2000 who is aged twenty could decide to travel into the past in the year 2001 when he is aged twenty-one, and arrive in the year 1066 aged twenty-one and (say) four

hours. Under these circumstances the moment of arrival in 1066 will precede, in external time, the moment in 2000 at which the decision was made to make the journey to 1066, while the cause of the arrival -- the throwing of a lever by Chronos in 2001 -- lies after the moment in 2000 at which the decision was made to journey into the past. Furthermore, whereas the moment at which the lever is thrown could either precede or follow the moment of decision relative to the external temporal reference (the traveller could make various intermediary journeys through time), it can only follow -- and never precede -- the decision relative to the personal time frame.

Popular fiction writers rarely consider the matter of the time traveller's freedom in isolation: problems of causal violation are by far the more popular, and the two are often intermingled. Hence, while R.A. Heinlein's short story *By His Bootstraps* begins with the traveller's frustration at his own inability to alter the course of events, it is the self-contained nature of his history that finally confounds the reader. Similarly, in *All you Zombies* it is the entirely isolated and closed causal loop that describes the origins of each of the four characters in the story which is revealed as the twist in the tale, rather than the total inability of the traveller to affect that loop adversely. Causality and freedom of will are intensely interconnected, and it is impossible to discuss the one in any detail without some reference to the other. However, in

this chapter every effort will be made to keep all references to causal relations to a minimum, since these are to be analysed in greater detail later.

The convoluted nature of Heinlein's stories makes them unsuitable as explanatory aids, but others have provided clearer examples. Anne McCaffrey is the author of a series of science-fiction/fantasy novels concerned with human descendants who have travelled to a planet with limited resources. As a result they are forced to make use of the native creatures, which include a large form of aerial lizard (dragons) with capacities for reason, communication, and time travel. McCaffrey uses the resulting problems in the fields of causality and freewill to stretch both her characters' imaginations and that of the reader. The following passage illustrates the difficulties encountered. F'nor, the rider of a brown dragon, has returned from a journey into the past and stumbled upon his commander (F'lar) and the latter's wife (Lessa), who are just contemplating the act that will send F'nor and other riders to the earlier date in order that more dragons may be bred in time to cope with an imminent disaster.

'F'lar, it's not working out! You can't be alive in two times at once!'...

'I don't understand.'...

'I can't stay. I'm here already. Too close. Makes it twice as bad. But I had to warn you...'

Before F'lar could move the brown rider ran, half crouched, from the room.

'But he hasn't gone yet!' Lessa gasped. 'He hasn't even gone yet!'

McCaffrey, 1983, pp. 191-192 (my emphasis).

As a result of this visit the following conversation takes place:

'What can have happened?' Lessa demanded... 'We haven't even told F'nor. We ourselves just finished considering the idea...'

'However, he has come back. So he did go,' F'lar remarked... 'Yet we now know the venture is not entirely successful even before it begins. And knowing this we have sent him back ten [years] for whatever good it is doing...Consequently we have no alternative but to continue with the experiment.'

Ibid., p. 193 (my emphasis).

It is the reasoning behind this claim, and the validity of the conclusion drawn, that will now be examined.

Section 1

The Challenge

Arguably the strongest argument for the claim that time travel will never be physically realised in the future lies in the total lack of any historical incidents involving a person claiming to be a time traveller. Stephen Hawking has recently drawn attention to this feature in his article 'The Chronology Protection Conjecture'. He challenges the claims of physicist J. Richard Gott of Princeton University regarding the potential for time travel into the past (using the space-distorting features of two cosmic strings hurtling past each other at 99.999999992% the speed of light¹) and further cites as 'strong empirical evidence' the fact that 'we have not been invaded by hordes of tourists from the future' (Hawking, 1992, p. 24).

Hawking's statement derives its significance from the assumption that the system of time travel under examination enables visits to a period before the invention of the time machine and occurs within one possible world. Should such a system ever be realised, it will follow that the consequences of time travelling activities begun in the future relative to us will already be in evidence. It is logically impossible for there to have been no time travel until the invention of a time machine, after which event

1. Hawking's paper is concerned with quantum effects and is not written for the layman. Simpler articles argue for a rejection of Gott's claims on the grounds that while each string is travelling at sub-light speed, the total system exhibits tachyonic energy and so violates special relativity. See: Deser, 1992; Travis, 1992.

past history -- that is, the time period antecedent to the first moment at which the time machine is operational -- is somehow altered to accommodate for the comings and goings of visitors from the future (as has been suggested by some poorly thought out science-fiction cinema). This is because there is only one occurrence in external time of any particular event, and change implies two states, those of before and after. Events, which are essentially temporal by nature, cannot, by definition, be altered. This is because alteration occurs in time, and in the case of an event would necessitate not the change from one state to another that may occur in objects -- such as a grey chair being painted blue -- and which preserves in time the existence of the previous state (it remains a fact of history that it was, at a previous moment, grey), but the entire negation of its original state so that it never existed in any other manner except that now being experienced. Hence there is no 'change', because there is no alternative state against which such change may be measured. Change could only be preserved if the alternative past occurred in one possible world that was accessible from -- or known to -- the occupants of another possible world in which a different set of circumstances obtained. It has already been emphasised that this discussion will be restricted to one possible world unless the nature of time travel should dictate otherwise; consequently, since the past cannot change, if a time traveller from the future were to journey to the Battle

of Hastings then it is a fact today that such a person was there at that place and time, even though we, in the 20th century, have not yet invented time travel.

This highlights a necessary condition of time travel: namely that all moments in time -- whether past, present, or future relative to any given moment in the external reference frame -- have equal value to the time traveller. The ordering of events personally experienced by Chronos need not agree with the ordering according to the external time frame that is the standard experience of those who do not travel in time. From Chronos' perspective, yesterday may have been the 23rd June and today the 22nd. Tomorrow may be 2019 AD and yesterday 3000 BC, while today is 1984 AD. All moments of time -- whether the dinosaurs are walking the planet, or man is visiting the stars -- must therefore be considered of equal reality to the time traveller, because any of those moments could be experienced in his personal present. This, in turn, has consequences for the latter half of the twentieth century; for although the 21st century appears to be mere potential from our perspective, for Chronos it is actual -- he can visit it and may even have been born there -- and therefore whenever he travels into the past he is proof that the future already exists, for if it did not Chronos -- being a product of that future -- would also not exist.

These two factors -- the equal status of all instants relative to the external time frame, and the existence of

consequences before their causes in external time -- must be constantly borne in mind throughout the following thought experiment and its subsequent analysis.

In an attempt to prove the capacity of his time machine to an incredulous observer, 'A', Chronos accepts the latter's challenge to bury a book, in a sealed container, at a time and place named by A. This item is to be grouped together with something more readily available at the time of burial than at the time of departure -- e.g. a newspaper of the day, or a letter written by someone presently unavailable due to physical distance or death. When he returns, Chronos accompanies A to the site and with him unearths the book and the temporal measure buried with it. Yet A remains dissatisfied.

He agrees that there would seem no reason to question the existence of the book in the place cited after the traveller's return. Since Chronos buried it there in the past, it must remain there if it has not been destroyed or moved elsewhere. But if the traveller intends to put it there anyway, and the consequences of his actions lie in the past, then (the doubter argues) the book should be available for discovery even before Chronos begins his journey. Therefore, if A now specifies another site for burial of the book, demanding that Chronos repeat the previous experiment with only that change, there would seem to be no reason -- originating in the fact that Chronos has not, in his

personal past, buried anything there -- why they cannot successfully excavate the site now. Since the argument appears coherent, a new location is requested and the experiment begun.

Success in unearthing the book would be in keeping with the results of the first experiment. If the book has been successfully planted in the past then it must be there to be disinterred at a time subsequent to that of burial, provided it is not moved in the interim: but the key word here is 'if'. Suppose that, after excavating the book, A argues that because they now have the item in their hands there is no reason why Chronos cannot refuse to travel into the past, or even destroy the book at an earlier stage in its life history before it can be buried. The book has already been unearthed, therefore no physical impediment to the experiment exists, and while it is true that a failure to bury the book in the past would result in a causal violation, nevertheless the book cannot disappear because this would entail a logical contradiction. This is because it would not be the case that the book was there and then it was not. If the book is destroyed before it is buried it *never was* in the hole, and therefore it will not disappear but *never have been*, and all memories of its being there would also *never have been* (see above). But if the book -- having been disinterred -- is already in their hands, that fact cannot be altered and there must, therefore, be some

explanation of its being there. In the world as we understand it, something as large and organised as a book does not spontaneously appear in the past merely in order to satisfy some future desire that it be there; and this chapter is concerned with the nature of time travel in this world.

What would happen if Chronos successfully destroyed the book before taking it into the past? In that event either the existence of an identical, but unconnected, book in the hole was purely coincidental, or they unearthed an earlier stage of the book just destroyed whose complete history has yet to be revealed. In the latter case, events in the future may explain its presence in the hands of the observer before the experiment as well as its presence in the hole at a stage in its personal history antecedent to its existence in A's hands. However, in that case the existence of the book in the hole would not have been a result of Chronos' actions, but merely a coincidence resulting from earlier events that culminated in its burial and subsequent discovery in the hole, as illustrated in Fig. 4.1.

If an identity relation is to be maintained between the book in A's hand and the book excavated from the hole, it is necessary that the book be in A's possession at a moment in its personal history that is subsequent to its burial and recovery. This is because the entire personal history of the book, from the moment it is seen in A's hand to the moment of its destruction, is known. At no point on that world line

(labelled 1) does the book disappear, nor is such a scenario possible if it is to be destroyed. To understand why this is so, imagine the book is taken from A at point * and carried into the past to be buried in the hole (see Fig. 4.2). Under this description, the world line that exists in the original diagram between points * and + would not exist, and the life history of the book would be a closed causal loop in which it is neither destroyed nor created but simply appears and continues to exist until it is carried backwards in time to the moment of its initial appearance (initial with respect to the external time frame -- there is no first instant with respect to personal time). Since the aim of the exercise is to destroy the book at a moment in its personal history that is anterior to its being placed in the hole, this solution is unsatisfactory.

If appropriate precautions are taken to ensure the book is destroyed at point 3 (see Fig. 4.1), then its existence in the hole will be coincidental and will not depend on the actions of Chronos. He can only take it back in time at a moment subsequent to its being taken out of the hole (line 2), and if he then uses that opportunity to ensure that its existence in the hole is a result of time travelling activities, the identity relation between the book in the hole and the book in A's hand is severed -- as shown in Fig. 4.3 -- and instead there are two separate books: one that comes into the possession of A and is then destroyed; one that exists in a closed loop and whose history consists of

being buried in a hole in the ground, unearthed, taken back in time, buried, and so on, as illustrated by lines 1 and 2, Fig. 4.3.

From the above argument it follows that the world line of the book illustrated in Fig. 4.1 is the only one that will both ensure an identity relation between the book in A's hand and that in the hole, and utilise backward time travel as a means to explain the connection. However, this solution not only fails to illustrate the doubter's arguments, but it also poses a problem for freewill.

The single book in this thought experiment can be destroyed because the occasion of its destruction occurs at the most extreme point in its open world line. Yet it comes into the hands of A at the culmination of a series of events that involve its backward temporal movement at a moment in its personal history that is after point 2 and before point 3. From this it may be inferred that a time traveller, although not necessarily Chronos, will take it back in time at some moment in the external future, and since the consequences of that act are already in existence -- A has the book -- the act must be performed. Hence the doubter's conundrum remains, albeit in a slightly modified form to that originally intended. The question now is not how the book came to be in the hole, but how it came to be in A's hands.

Let the following be assumed for the sake of simplicity: that (a) there is only one time traveller; (b)

no object bearing an identity relation with the book in A's hands has ever been transported by Chronos at any previous point in his personal world line; (c) the book's final location in A's hands is a direct result of an act to be committed by Chronos at a moment in his personal future. Does it follow from this that Chronos' freedom to act according to the dictates of his own will has been compromised?

It is a fact that once any act -- be it as spectacular as the murder of a warrior before his most famous battle, or as simple as picking up a leaf -- has been committed by Chronos in the external past, no attempt to refrain from performing such an act can succeed under the present description, because that would generate a logical contradiction -- even though the act is yet to occur in Chronos' personal future. However, I will argue that this is not a reflection on the freedom, or otherwise, of the time traveller, but merely a misinterpretation of events arising from our intuitive (if not consciously acknowledged) assumptions of an absolute, rather than a relative, temporal reference.

Section 2

Occurrence Versus Experience

The assumption that the book in the hole and the book in A's hand are physically identical but temporally different -- the one in the hole being at an earlier object-

stage in its personal history -- combined with the fact that it is in A's possession at a time that is later in its personal history, but earlier relative to external time, has led to the conclusion that it must inevitably be carried into the external past at some future moment (future from both the personal and external temporal perspectives). Since the book need not communicate any information with regard to precisely when and how it was/will be relocated in the past, Chronos could be as ignorant of those facts as any person who is not a time traveller. It is not, however, ignorance of the future that preserves his freedom; and if ignorance does not provide sufficient grounds for a claim to freedom, then neither does knowledge deny the possibility of that claim.

There is no logical reason why Chronos could not make a video of himself with the intention that it be carried, by way of the time machine, to a moment in the past that preceded the time of the recording. At that point the tape could be handed to Chronos' earlier self, who would then be in a position to view events that had not yet occurred from his perspective. In this way he could be fully conversant with events that are logically unalterable -- because they lie in the past world line of the video -- but which he would appear to be in a physical position to change -- because they lie in his personal future -- and nevertheless preserve his freewill. The reason why we intuitively deny Chronos' freedom of will is because when we imagine him

giving the video to his younger self, we assume that what that earlier self will see is a recording of a person who is acting in ignorance of the contents of the tape. The earlier person-stage of Chronos, having been apprised of that information in advance of the events recorded upon the tape, would appear to be in an ideal position to behave differently. It would therefore seem reasonable to assume that if he does nevertheless carry out to the letter the actions recorded upon the tape, there must be some 'external pressure' that either restrains him or forces him to act in a particular manner. Chronos assumes that, for example, if he should attempt to prevent himself from picking up a piece of paper, something will force his hand, while he remains ignorant of what this 'something' is. Yet in making that assumption, he is also making a fundamental error, in that he is confusing the number of occurrences of an event with the number of *experiences* of that same event available to him, and it is this distinction that may be used to preserve the traveller's freedom.

Figures 4.4 and 4.5 (which have been simplified for the sake of clarity) illustrate what in fact is the case, and Chronos' interpretation, respectively. In the former there appears what may be termed a temporal loop. The recording is made by someone who has already seen the results, and is therefore fully apprised of his actions before committing them. Every subsequent act is therefore a consequence of that knowledge. Yet because the event in fact only occurs

once, Chronos is in no better a position than a person who is not a time traveller and who views a recording of his behaviour after the event. The difference lies in the fact that whereas such a person can *physically* experience any particular event only once, and cannot be in possession of *knowledge* regarding any event in his personal future, Chronos can revisit any temporal moment a potentially unlimited number of times (see Fig. 4.6). He can witness his own future actions from the position of an observer, and thus acquire knowledge regarding those events. Each time he will do so from a different perspective, because he cannot occupy the same physical space at the same time as two different person-stages (see Chapter 1). However, that limitation aside, the potential of his position for providing information regarding future events would appear limitless.

In Fig. 4.5 Chronos' error is made apparent. The two lines represent, in fact, the two *experiences* that Chronos has of the event, but that he has interpreted as two different *occurrences* of the same event, with each occurrence occupying the same physical place and time. In the first, the person being recorded has no knowledge of the contents of the tape in advance because the recording has yet to be made, whereas in the second he is fully informed and attempting to alter it, the recording having been taken back in time to be viewed in advance.

It is this confusion which leads Chronos to the

mistaken beliefs that (a) he can change the past because the origins lie in his future, and (b) he must be directed by some outside influence if he cannot. In fact, what Chronos sees on the video are the actions of someone already aware of what will happen and behaving freely with that knowledge in mind. The temptation to imagine that the event itself occurs an infinite number of times is a result of the peculiarities of closed loops in time. The automatic human response is to ask which came first -- the recording of the events, or the time traveller's viewing of the recording. Since the viewing of the recording takes place earlier with respect to external time, it is tempting to place that event first. Yet the recording itself must be made in order that it can be watched, therefore this event is given precedence. Finally, the person in the recording has already seen the video that Chronos is now watching, and so begins a vicious circle. Nevertheless, the event in question only occurs once, as does the viewing². The particular paradoxes surrounding closed time-like (or causal) loops will be considered in more detail in the next chapter. One aspect may be examined here, however, because it has some bearing on the problems presently under consideration.

The following scenario, which is normally applied to problems of causality, is an example of what has been termed

2. Chronos could view the tapes many times before making his journey into the past, but each such event occupies a separate period of external time, and only occurs once on each such occasion. The first time he watches the tape is only ever the first time, it is not also the second and third relative to the external time frame, or even -- in this example -- the second or third time relative to the same moment in his personal time frame.

a 'bilking experiment'.

Chronos decides to travel back in time to murder his father at a moment previous to that of Chronos' own conception. The method of attack chosen employs brute force rather than automated means since this removes the possibility of a mechanical failure and, he believes, enhances his chances of success.

Even before Chronos begins the exercise it is already apparent that he cannot succeed because, as Horwich succinctly puts it,

...only those who fail will ever be in a position even to make the attempt.

Horwich, 1987, p. 117.

Yet while the answer to the question *why* he will fail has already been determined, it remains to discover precisely *how* that failure will be engendered.

It is conceivable that, while he is lying in wait, Chronos might find himself joined by a large number of people, all of whom are himself at various future stages in his personal existence. Older versions could assure him that every one has a hand in the attack, but in each case something occurs that frustrates their efforts. Chronos may thus be presented with the imminent failure of a future event before every attempt made in his personal time --

which in turn could be any number physically possible within his life-span -- and, despite having this foreknowledge, his future selves have nevertheless made the trip. Furthermore, this knowledge is not presented in the form of a non-interactive and therefore unresponsive video recording (as in the example raised above), but is instead the verbal testimony of several individuals standing at the site of the event seconds before it occurs. Each, including the earlier stages, may be questioned by the others and may even reveal the nature of the problem that led to the failure of the attempt made by the previous person-stage. Here there would seem to be ample opportunity to agree a change of tactics, but because, for each speaker, the events relating to their particular error lie in the personal past of that person-stage, and are therefore unalterable (or else their memories of those events would never have existed), there would seem to be no alternative but to conclude that the time traveller is causally determined.

There is, in fact, no justification for the assumption of this extreme position, for in this example also there arises a confusion between experience and occurrence. The same event -- the attempted murder of Chronos' father -- is experienced by Chronos many times, and from many different viewpoints, but the event itself -- which includes the full complement of individuals making the attempt -- only occurs once, as do the conversations before the attack. The illusion of multiplicity is generated by Chronos' repeated

experience of the event at different moments throughout his personal time line, but the necessity of his past-directed temporal journey after each attempt, in order that he may return to the moment of the event, is sufficient proof of its singular nature under the present description (i.e. within one possible world). Arguments for cyclical time -- e.g. Weir, 1988 -- are not being considered, because travel into the external future in order to experience a qualitatively but not quantitatively identical event is not, by definition, the system of time travel presently under consideration. The external time event experienced by Chronos is quantitatively and qualitatively identical, even though Chronos' personal experiences of that one event are quantitatively and qualitatively different due to his changing physical position and increasing age relative to the personal time frame.

At each stage Chronos sees his earlier and/or later selfs acting in full awareness of every other stage and incident in the fight, and their actions are shaped by that awareness in a similar fashion to the way in which the actions of any other individual are shaped when a person informs them they are going to do X, and they decide to do Y in an effort to disprove the prediction. This might be termed an 'Oedipal' determinism. The event cannot be changed, and therefore either it must be assumed that the very act of attempting to thwart it is the cause of its successful outcome, or arguments must be presented

supporting the existence of an outside influence shaping events. There is no empirical justification for the latter assumption based on our present experience of space and time, however, and the introduction here of the experience versus occurrence distinction that was made earlier further reduces the scope for such empirical support. In addition, such a force would only come into play when a time traveller attempted to change the past, and would necessitate the postulation of a number of new physical laws that are only applicable under such circumstances, where they would have priority over all other laws. On the other hand, the 'Oedipal' explanation appears to support the logical outcome of events for which fore-knowledge is available without recourse to such extraneous forces, thereby minimising the number of factors involved.

Oedipus did not know all the relevant facts, however, and Chronos does. Why, therefore, would he *repeatedly* attempt the murder of his father when he already knows (due to logical necessity and verbal information) that he must fail? The experience/occurrence distinction, while logically defensible, is intuitively disconcerting, and if the introduction of an outside force is unacceptable, the only possible explanation under the circumstances -- the denial of time travel as presently described -- remains logically indefensible by means of the present arguments. There remains one other option, however, and that is to examine the question of whether or not there exists a logical

argument to support the contention that the above situations will simply never arise.

Section 3

Sufficient or Necessary?

In order to answer the above question, it is simplest to return to the challenge posed by A and re-examine the causal relation between the discovery of the book in the hole and its appropriate planting as described in section 1. This in turn necessitates an analysis of the application of sufficient and necessary condition labels to these circumstances.

Although success in excavating a book physically identical to the one in A's hand does indicate a need in the book's personal future for a backward temporal journey to a moment anterior (in external time) to its existence in A's hand (see Fig. 4.1), this need is not the cause. The only legitimate conclusion is that a cause must exist, and while that cause may be its actual presence in the hole -- that led the time traveller to make an assumption regarding his own freewill, resulting in his stepping into the machine and travelling backwards in time to plant the book in A's house -- this is by no means assured. The book could be left until after Chronos' death, and only then, perhaps by accident, be taken back in time and sold or left behind to be bought by A in a bookshop. It may be taken back by someone during Chronos' lifetime, or even make many trips backwards and

forwards through time before finally falling into A's hands. A himself (or an ancestor) might have been taken into the future and seen the book, bringing it with him when he returned to his own time. The list of causes for the presence of the book both within the hole and in A's hand is potentially infinite, and the only essential conditions are that it is not damaged irreparably before it enters A's possession, and that it makes at least one trip into the past at some moment in its history after the excavation.

Similarly, failure to find the book is a sufficient but not a necessary cause of its not being there. If the book is not disinterred in that place, nothing one can say or do will make it appear there -- for it cannot spontaneously materialise as if by magic and the cause still be attributed to time travelling activities. Consequently, no further effort need be expended in making the attempt, and this is a sufficient reason for the original failure to excavate the book: it is not there because no one made the effort to put it there, and no one made the effort because it was not there. Although this explanation is sufficient to account for the book's non-existence, it is not the only solution possible. Chronos might make the attempt and be distracted; his machine might fail; or he might die in the enterprise due to a malfunction. The book might be destroyed, or the machine lost, or the book may be taken into the future or too far into the past and never retrieved. Even if it is placed in the hole, it might be removed by an animal or

human before the test dig. Once again the potential is infinite, and the only necessary feature is that it must not be in the hole at the precise moment of the experiment.

From the above it follows that although the existence of the book, both in the hole and in A's hand, may be causally self-explanatory -- as outlined above -- and this is a sufficient condition of the actual circumstances, it is not a necessary one, and therefore it is no guarantee of the time traveller's future behaviour. Consequently it need not be regarded as proof of the existence of an externally determining factor governing the actions of the time traveller.

With this in mind, a re-examination of the experiment may be presented in order to supply an answer to the following question: which is the more likely? That the book is discovered in the hole, or that it is not? If A intends to destroy the book in his hand after the copy in the hole has been unearthed, and he further intends to destroy the buried book, then I suggest that the buried book will never be found. For if it is discovered and proved identical, any subsequent attempt to destroy both copies must be foiled, regardless of how simple or complex the process. Matches would fail to strike or simply not light the paper, attempts to tear individual pages would be thwarted, and acid would either fail to strike the book, or the bottle would prove not to contain the substance its label purported to provide. Although each individual failure would be explicable, the

cumulative failure would not: partly because it would be a violation of presently accepted levels of probability, and partly because such violations must necessarily occur on every occasion that one attempts a bilking experiment, thereby compounding the problem. While this is not a logical reason for rejecting time travel as so far defined, it is intuitively unappealing, and it necessitates a series of qualifiers that a simple failure to find the book in the first instance does not.

The problem becomes more acute if, instead of the book, consideration is given to the position of a rational being attempting the logically impossible -- for example, the repeated attempts perpetrated by Chronos on his father's life that were cited above. The existence of several temporally separate person-stages of Chronos, all communicating information to an earlier stage regarding the latter's future, has not been proved logically impossible, but the question remains as to why he would repeatedly visit the same time and place once the inevitability of failure had been established. The mental confusion experienced by Chronos as a result of repeated encounters with various future person-stages at such an event is difficult to imagine. Chronos does not know how they came to be there, nor why (unless, of course, he should ask), but their existence is proof that somehow or other he will occupy this particular time and locality on many occasions in his personal history and, despite both numbers and knowledge,

fail on every occasion. The repeated appearances of an inanimate object such as a book seem explicable on the grounds that the history of such a non-reasoning object is a matter of chance, but with the introduction of a rational being, aware at one and the same time of what has happened and will happen, such explanations seem inadequate. Chronos could be apprised not only of the current situation of a future person-stage, but also of the method by which it was achieved, and be aware that this information was known to the stage telling the tale and so on *ad infinitum*, yet it would remain a fact that nothing could be done to alter what had, for the later stage, already happened³.

Similarly, if Chronos is aware that his trip must end in failure, then reason dictates that to make the attempt is pointless, because all he could achieve in so doing would be a greater understanding of why he failed. Yet not to make the attempt at all is also an explanation of why he failed. The difficulty is that it is also a self-verifying explanation -- he failed because he did not try, and he did not try because he failed. This would indicate the existence of a closed causal loop that is, at this stage, psychologically dissatisfying due to the lack of any external explanation⁴.

3. In Heinlein's *By His Bootstraps*, the traveller's inability to alter the course of events is furthered by both the inebriated state of the earliest person-stage involved -- which proves detrimental to later memories -- and the hurried nature of the events themselves, which inhibits questions. The driving force behind his continued fulfilment of role is a mere by-product of over-excitement or ignorance and is never fully explained.

4. As proof of this, imagine that the question 'which came first, the chicken or the egg?' were 'resolved' by means of the relocation of a number of fertilised eggs in the past.

Even potentially useful side-effects prove worthless under this examination. It is conceivable that a friend of Chronos, finding herself in danger, could be rescued at a fortuitous moment by the sudden appearance of the time traveller, whose remarkable timing is only explained later when she (let us call her Vremya) questions him and discovers that the person-stage she is presently communicating with is an earlier one to that which saved her. Now informed regarding the time and place of rescue, Chronos is capable of fulfilling the task, but should he? It may be argued that so long as he does not, he is assured of his own safety. Nothing can prevent him from delivering Vremya from her fate, and any accident severe enough to affect this would create a paradox. Chronos' future survival, therefore, would appear guaranteed until he makes the trip. Yet this is not so. Chronos has no means of proving that the person who saved Vremya was identical with himself. If he was not, Chronos' future remains open and insecure inasmuch as it pertains to this matter. If the person who saved Vremya was a later person-stage of Chronos, he still lacks knowledge regarding the circumstances of that rescue, even though he knows it must occur, and because it lies in Vremya's past any attempt to delay the rescue must end in failure or contradiction.

Throughout the above examination, the importance to the argument of the conditions that obtain on the first occasion, relative to the external time frame, at which a

part of the paradox exists has proved pivotal: whether or not it was Chronos who rescued Vremya; whether he made the attempt upon his father's life once, more than once, or not at all. Decisions regarding future behaviour *can* -- but *need not* -- be based entirely on knowledge of the events concerned, and a minimal understanding of human nature warrants the assertion that any decision made by an individual in possession of such knowledge will be, at the very least, influenced by it. For example, although Chronos cannot prevent the Black Death -- because it is an historical fact -- he can cause it, either by carelessness or by deliberately arriving in the fourteenth century while infected with the disease. In the latter case, his awareness that the plague decimated the country at that time may lead him to seek a peaceful demise in the historical period in which the nature of his death would neither generate an anachronism nor cause unnecessary suffering, rather than returning to his own time and risking another generation. In this way the fact of the Black Death -- the unalterable nature of which diminishes the moral repugnance associated with the traveller's actions -- would be the cause of his choice of arrival time in his personal future. On the other hand, the choice could be an entirely arbitrary decision, without any basis in knowledge of the conditions that obtained in that century. Under these circumstances it is still possible, although not necessarily the case, that Chronos will prove to be the cause of the ensuing disaster

without being aware of the fact, if he has unknowingly contracted the disease at an earlier stage in his personal history. The initial circumstances are therefore an indication of how the traveller *might* behave. He is logically incapable of preventing the Black Death, or any other actual past event -- hence there already exists information regarding what he cannot do -- but any moment of poorly documented history may provide an opportunity for the time traveller to discover that he has a place in the causal scheme which shaped that event, and from this situation may be derived information regarding what he can do.

Inasmuch as Chronos does not change the event, but merely discovers his place within it, he does not differ significantly from any other being with causal potential. If the future is open, then no one is in a position to change it, because there is nothing to change -- there is only the discovery of that being's position within the events which go to shape that future. Similarly for the backward-moving time traveller, because the past only occurs once there is nothing to change, and consequently he can only discover his position within the events that went to shape that past. The difference between the two positions stems from the assumption that the ignorance regarding future events that is displayed by those who are not time travellers is due to the fact that there is nothing to know, the future having a different ontological status to that of the past. However, if time travel within one possible world can exist, then the

'open future' is open only in so far as we have yet to discover what we *did* do when viewed from a later perspective. This puts the free status of Chronos and those who do not time travel at exactly the same level. He, being from the future, is already aware of how we will behave, because we are in the past relative to him, and he may also be aware of how he will behave in his personal future (provided those events are in the external past relative to his moment of departure). Consequently, either it is the case that both those who do and those who do not time travel are free, or both are determined, and it has been argued that the time traveller is free.

This brings the argument full circle to a point raised earlier regarding the equal status of past, present, and future. If there are discovered unmistakeable signs of a time traveller's interference in the past or in the present, then it will follow that time travel must be invented at some point in the future; but if no such signs should exist, what hope is there for time travel? The physical inability to verify the exact structure of events in the past leaves the way open to future research that includes this study, but if it is a fact that there have been no time travellers in the past would that research be necessarily unproductive?

This question raises an interesting point in that whereas if a person fulfilling the description 'time traveller' exists, he may consider himself a free agent, if such a person *qua* that description does not exist, then no

attempt to enter the past can succeed, simply because it *did not*. He is therefore not free to be a time traveller if he was not one previously in external time, although he is free to try. This is not to claim that he is causally determined not to be a time traveller by the fact that he was not one, only that the non-existence of a time traveller in the past is proof that any attempt must fail, for whatever reason, and may in itself be a sufficient condition of the potential time traveller's decision not to try.

Everything argued above need only be the case if one insists on an adherence to a system of time travel contained within one possible world. With the introduction of an alternative worlds thesis the appearance of determinism might be removed, together with the problematic non-existence of an historical time traveller (as far as anyone is aware), thereby enabling the continued useful study into the possibility of manned time travel. Consequently it is to an examination of this solution and the problems arising from it that the next section will be dedicated.

Section 4

Possible Worlds I

Human beings have a great propensity towards the asking of counterfactual questions, or the statement of assumed counterfactual results, such as, 'Would I have caught that plane had my train not been delayed?', or 'If you hadn't left that box in the doorway, I would not have fallen over it'. When a time traveller travels into the past in the hope of changing that past, he is posing and attempting to answer similar questions. He thinks he is asking 'What would have happened if X had occurred rather than Y (which did occur)?'. In fact the question is 'What would happen if a time traveller went into the past and made X occur, rather than Y?' The consequences of these two questions are different.

In the first, the proposer is trying to determine what might now be the case had a certain key event been resolved differently: for example, if Hitler had not embarked on Operation Barbarossa. In this model, the people who existed at the time of the key events had no knowledge of the future outcome of any given decision, and so either the choice could have been the result of a long stream of previous events, or it could have depended on the simple tossing of a coin. In the asking of this question an implicit assumption is made, namely that there is an answer that could, in principle, be discovered were it possible to examine

thoroughly the complex interplay of cause and effect stemming from the incident cited. The fact that if this counterfactual supposition had been realised, the answer to the question, as an answer, would not be appreciated -- because neither the question nor its proposer would exist in their present form -- is resolved by means of thought experiments. These enable the preservation of the two alternatives -- that which occurred and that which might have occurred -- and their separate consequences, and in this manner the self-defeating aspect of the question is circumvented.

When the question 'what would happen if a time traveller went into the past and made X occur rather than Y?' is raised, the agent can be fully conversant with the immediate results of one choice, because they will lie in the past relative to the moment of his departure in the time machine. The natural assumption is that a person in such a position could make a difference, and whereas, in the earlier question, the problem was that without the introduction of a thought experiment the answer could not be appreciated as such, here it is that the traveller, in so doing, would be affecting his own past and memories, and thus the cause of his actions. Yet if the sole cause were negated -- the traveller being the only person with the knowledge of the future required to attempt such an act -- the act would not be committed and a bilking situation would obtain. Nor should it be imagined that the traveller could

pass on his information to someone else who then performs the necessary act, for here also the cause of the act -- in this instance, the information divulged by the traveller to the agent -- would not (and indeed, never did) exist and therefore the act would not occur. (On the present findings of this thesis it is perfectly consistent for a person from the past to be aware of the future, provided that information is never used in such a way that it might adversely affect the future from which the information came.)

Were time travel a reality, questions regarding Chronos' powers to affect the past would need to assume a possible worlds thesis. Only then would it be legitimate to assert that an answer to the counterfactual queries raised had any genuine ontological status. The time traveller's existence would be proof that one world -- the one he was born in -- had been realised, and the past of that world cannot be changed for the reasons outlined above. Thus the time traveller who is successful in changing the past must enter an alternative possible world, as real as the one he left.

Such a bald statement requires qualification: what assumptions must be made in order to permit such a claim? What would an alternative possible world that may be visited by a time traveller consist of? How can it be integrated into the system of time travel so far outlined in this thesis? All of these questions will now be considered.

The most famous exponent of 'modal realism' -- the theory that every possible (i.e. internally non-contradictory) alternative is realised in a multitude of equally real possible worlds, our own being one among many -- is David Lewis. In his book *On The Plurality of Worlds* he defines possible worlds as he conceives them.

There are countless other worlds, other very inclusive things. Our world consists of us and all our surroundings, however remote in time and space; just as it is one big thing having lesser things as parts, so likewise do other worlds have lesser other-worldly things as parts. The worlds are something like remote planets; except that most of them are much bigger than mere planets, and they are not remote. Neither are they nearby. They are not at any spatial distance whatever from here. They are not far in the past or future, nor for that matter near; they are not at any temporal distance whatever from now. They are isolated: there are no spatiotemporal relations at all between things that belong to different worlds. Nor does anything that happens at one world cause anything to happen at another. Nor do they overlap; they have no parts in common, with the exception, perhaps, of immanent universals exercising their privilege of repeated occurrence....There are so many other worlds...that absolutely every way that a world could possibly be is

a way that some world is.

Lewis, 1986, p. 2.

The system of possible worlds presently being proposed for the time traveller is similar to Lewis's system in respect of their equal reality with this one. From the perspective of a person living in World α -- that being a world in some way different to our own -- our world is as unreal as theirs is to us, but to a person living in any one of these worlds, that world is real. Under this description, reality becomes an indexical matter. However, in many ways the system employed by a time traveller is necessarily different to that outlined above.

For David Lewis, the value of a system of possible worlds lies in its capacity to solve problems in the logic of modality. Here, they are being used to resolve subjective objections to the nature of the traveller's freedom of will, and they do this by enabling him to 'change' the past by providing a system of equally real possibilities that can be compared by the traveller and -- via his experience -- by any person in communication with him. Such different aims will necessitate different understandings of what is meant by a 'possible world'. As with the Lewisian system, these worlds are not finite in number, and each of the infinite variety of time travel worlds consists of other 'lesser-worldly' parts, but there the similarities end.

It is necessary for the traveller to move between

possible worlds; consequently, Lewis's claim that they are spatio-temporally and causally isolated must be abandoned, and each must be considered physically accessible from this world, either directly or transitively (i.e. via one or more other worlds). World X might be causally affected by activities in World Y via the movements of the time traveller, and World Z transitively affected by the birth and subsequent actions of the traveller from World X via World Y. The difference between Lewisian and time traveller accessible worlds may be more easily understood in graphic form.

In Figs 4.7 and 4.8 respectively, the Lewisian possible worlds system is compared with one that uses alternative branching worlds. Each line in Fig. 4.7 represents a complete Lewisian possible world. There are no spatio-temporal relations either existent or possible between them. On the other hand, in Fig. 4.8 (which has been much simplified for the sake of clarity) the alternatives are shown as branching, with any one possible world (for example, this one) represented as a particular path taken among the infinite possible choices, rather than just one branch alone. Thus the left-hand fork above the point labelled 1066 is the one actually taken, while the right-hand fork is the alternative. This might represent the moment at which Harold chose to follow the apparently retreating Norman forces down the hillside, rather than await their repeated attacks and grind them down from above.

At a later moment another choice is presented, and this time it is the right-hand fork that is chosen, and so on. The combination of all these decisions, and an infinite number of far smaller ones, may be traced as the path of the actual world as we understand it. In this way an obvious question may be answered: namely, if the possible worlds are accessible to the time traveller, why are they not accessible to us? In fact they are, but because (unlike Chronos) we are never, by definition, in a position actually to experience the alternative that we did not choose, we believe that it does not exist except, perhaps, as unrealised potential. Every decision made actualises a potential that is subsequently deemed a part of the 'real world'. If the time traveller, by his actions, changes that decision then, if he is to continue to exist in his present form, he must enter another possible world which then becomes actualised from his point of view.

If there are alternative worlds accessible from this one, the time traveller may prove to be the key to such 'inter world' travel. That is because only he could affect and experience the 'change' that would be a necessary feature of such movement. This 'change' would be only an appearance generated by the difference between what the traveller knows to have been the case in his own past in World X, and what he presently witnesses after travelling backwards in time, affecting events, and thereby entering an alternative world, Y -- hence the use of inverted commas.

However, because, from his perspective, subsequent events are different to those that he recalls as having occurred at that time, the appearance of change under these circumstances might be considered sufficient to warrant his use of the term, even though persons occupying either world without the benefit of the traveller's experience would not consider any change to have taken place.

This raises questions regarding the nature of change under these circumstances. Can it be said to have taken place only if it is between two differing states of one object in one world, or can it be invoked with equal force to cover the difference between qualitatively similar (up to the moment in question) objects or events occurring at identical times across worlds? Without the linking factor of the time traveller this last suggestion leads to absurdity, in that a person might claim there to have been a change between the colour of the chair upon which they are sitting (a colour that will remain identical for the foreseeable future) and the colour of a possible chair in another world that will be painted in the next five minutes. This would indicate that while change need not occur in one world, if it is to be recognised across worlds there must be a unifying consciousness within which not only must a before and after aspect be established, but the ontological status of the two have equal value. Whether a person living in World Y, who is told by a time traveller of events in World X, would be capable of assigning such equal status to those

events is debatable. It is also a reflection on the nature of change within one world over considerable periods of time, in that in both cases change is only registered by the comparison of present experience with the memories of those long dead, that information being acquired transitively or via written documents. Similarly, would the person in World Y express his understanding of the contrast between his immediate experience and that reported to him by the time traveller from World X as an example of change, or mere difference? It may also be noted that whereas within one world change is normally a term reserved for the altered state of an object, between possible worlds it has become a term applicable to the differing experiences of an event by the traveller. This was the purpose of the introduction of branching worlds at this juncture, but are there grounds for the claim that two events -- neither of which has causal priority except within the experience of the time traveller (an arbitrary relation at best) -- may be said to represent the two stages of change? Although both originate in the same world, at the moment of partition the two become physically isolated as well as qualitatively different. Furthermore, relative to an extra-world observer each occurs at the same temporal instant. Once again, this was one of the reasons for introducing the system of branching possible worlds, but further study into the causal relations that exist between worlds and between the events contained within them is clearly required before an entirely satisfactory

understanding of 'change' as experienced by the inter-world time traveller can be established. Since the analysis of causal relations, both within one world and inter-world, is to be the subject of the following chapter, further discussion of this topic will be reserved until then.

To return to the graphs mentioned earlier, it may be noticed that in Fig. 4.8 the direction of time runs up the vertical axis from the past to the future, indicating that Chronos may travel from a moment in the future (labelled 3000) into the past (labelled 1066) and then, by affecting the key decisions at the battle, advance through time on a different path. This indicates that the passage of time for every possible world is the same, and therefore if Chronos wishes to visit an alternative 1066 AD, he must first travel backwards in time to 1066. He cannot move directly from 3000 to 1066 merely by finding a method of travelling between worlds and then somehow choosing one most similar to our world in 1066, because to do so would be to invalidate the claim to time travel in favour of the no less intriguing, but nevertheless separate, claim to inter-world travel alone. In this last lies a clue to the inadequacy of the Lewisian description for the present purposes.

Were Lewis's possible worlds formula to be employed, no time travel that uses them could take place because, as Lewis himself makes clear, there are no spatio-temporal connections between his possible worlds. It would therefore be legitimate to suppose that World X is this world, World Y

is a world in which the closest counterpart to England on the planet Earth resembles England as it was in 1066 AD, World Z is one in which this planet's closest counterpart resembles a post-nuclear future, and so forth. By travelling between them (*per impossibile* where there are no spatio-temporal relations) Chronos would achieve the appearance of time travel without actually accomplishing it, and although this would solve the paradoxes, it is not an acceptable alternative.

Temporal paradoxes are the result of a clash between those acts that a physically unrestrained and mentally unimpaired individual should be capable of performing, and what can actually occur given the known facts of the event in question that lies in the past. A freely acting individual should be capable of recovering a pen from the floor; however, if an examination of the site twenty minutes later reveals that the pen has not been retrieved, no amount of temporal activity in the past of that world can change the fact. Should the traveller move between worlds but not backwards in time, the problem would be resolved but at a price. Chronos would be free to pick up the pen, but because it is not identical with the pen he wished to recover the act would be no more significant than if he were to move into another room and pick up a similar pen lying on the floor there. It is not the event alone with which this thesis is concerned, but also the moment of its occurrence. If Chronos merely moves into another room or another

possible world, he will not be moving the chosen object at the time in question, but merely a similar object at a time that, at best, *appears* to be the moment in question, but is not. This situation is illustrated in Fig. 4.9. By moving directly between possible worlds Chronos may, if he is fortunate, witness events that appear identical to those which occurred on Earth in 1066, 1665, and 1940, but the similarity is no more than a coincidence. Arrows indicate the traveller's personal experience of the passage of time as he ages in the normal way, and because the illusion of time travel has been preserved, the temporal direction of each world accessed by the traveller in this example must have been such as to appear normal to him. No more general temporal arrow may be included, however, because no genuine relations of time or causality exist between these possible worlds.

The branching system, on the other hand, preserves both the need for temporal movement and the identity relation (as defined) between objects and events in one world and its alternatives. This is due to the fact that in order to enter a branch, Chronos must first travel backwards in time and attempt to alter the pattern of events so that they no longer match those that form the recorded history of his time line -- for example, by enabling Harold to win the Battle of Hastings. It is only when an attempt is made to alter the past relative to the actor making the attempt that the need for an alternative world becomes necessary, for

then it can resolve the potential paradox inherent in the act.

With the introduction of communication between possible worlds comes the need to reconsider the identity relation. The present system cannot account for the relation between persons occupying equivalent positions in worlds visited by the traveller (e.g. William in 1066 W1 and William in 1066 W2). In order to resolve this problem, just as temporal parts were introduced to enable an identity criterion for the time traveller, so now must be added to that the concept of modal parts. Every person and object occupying the time and place of the Battle of Hastings must be understood as having a modal part in the alternative world that Chronos enters. These modal parts are virtually indistinguishable from those persons and objects occupying the same relative position and time in Chronos' original world, and they have a common root in this world: the branching taking place at Chronos' moment of arrival. These are the people we would have been had we behaved differently at the time. The status of the options available is of equal value before a decision is made, and if Chronos ensures that the choice favours an alternative to that which is recorded in his own world's history then, because Chronos cannot cease to exist retroactively, both his world (the one he was born in) and the world his activity brings about must be equally real, both to themselves and to Chronos when he is occupying them.

This raises two interesting points: one is that if the

persons occupying the time at which Chronos affects his alterations have modal parts in all possible worlds in which they exist, surely Chronos has as well, for he is no less human and therefore should enjoy all the same qualities. Consequently, Chronos could well run into his own time travelling alternative modal part, and this raises further identity problems. Second, it follows from the branching system outlined above that no person attempting to *re-create* the circumstances of Chronos' departure on his journey backwards in time could do so, which in turn indicates that the problem of determinism has not been solved, but merely removed one stage in the argument. The reasoning behind this second claim is somewhat obscure, however, and therefore requires further clarification.

Section 5

Together, Or Not At All

Imagine Chronos preparing to travel backwards in time to change the outcome of the Battle of Hastings. When he arrives at the required time and place he takes a gun and shoots William, staying to watch the events unfold. Now suppose that a second time traveller, Vremya, is added to the scenario. She wishes to intercept Chronos and witness with him the results of his activities, but only hears of his intentions after he has departed. Climbing into her time machine, Vremya travels back to the moment of Chronos' departure in his machine. But if, as a matter of fact, she

was not in the laboratory at that instant, no attempt to change that fact while remaining in this world can be successful. Assuming that laboratory technicians have already informed her that Chronos left alone, if Vremya is to be successful in her attempt to join him she must either make arrangements with Chronos before his departure for a meeting at some designated time and place where he can pick her up after leaving the laboratory, or she must attempt to recreate the circumstances under which the change Chronos planned to enact occurred. In either case the results are unsatisfactory.

Should Vremya arrange to meet with Chronos, then the moment of the meeting must be in the future relative to the moment of Chronos' departure. This is because if the meeting is in the past relative to his departure, it must be arranged in one of two ways: either Chronos met Vremya in the normal manner (i.e. without the aid of a time machine), or he used a time machine to travel backwards to a moment before his departure. In the first instance, Vremya would already be aware of Chronos' intentions before his departure and therefore would be with him in the time machine at the moment of his departure⁵. She was not, and consequently this does not describe the situation that requires analysis. On the other hand, if it is suggested that Chronos take the

5. It is worth noting that it is improbable that Vremya could follow Chronos into the past using her own machine, because the very act of using an independent method would enable the introduction of further variables with the potential to move her into another world that is separate to that occupied by Chronos.

active part in the arrangement, and use his machine to travel backwards in time to meet her the week before his departure for 1066, then it follows that had the meeting occurred and Vremya been duly collected she would not exist at the later date to ask for the lift⁶, and in that case he would not offer it and a bilking situation would obtain. On the other hand, if it is supposed that either one or both agree to travel backwards in their respective time machines to meet at the same time and place a week before Chronos' intended departure from the laboratory, then deterministic problems arise. For either the world a week later (i.e. at the moment of departure in the machine(s)) is as it is as a result of Chronos' and Vremya's meeting -- in which case they could not fail to meet since it is a part of history -- or the state of the world after the time of the meeting is not a result of the encounter, but instead reflects the consequences of a history in which no such meeting occurred. In this case it follows that, in order to be successful, the meeting must take place in an alternative possible world. However, while this last appears acceptable on a cursory examination, more careful study reveals that it cannot be the case.

The effect that Chronos had on the events of 1066 (as cited above) did not include the existence of Vremya in that

6. After Chronos has visited 1066 and effected his alterations it will be virtually impossible for him to return to this world; consequently any suggestion that she be returned to this world at the appropriate moment to request the lift is unrealistic. It would assume that Chronos could guarantee to return to this world after he had moved into another.

world. Furthermore, he did not have her with him at the moment he travelled back in time. Consequently a successful encounter by Vremya in an alternative possible world with Chronos could only arise if the man she met were not a later person-stage of the man who left the laboratory, but a modal part of Chronos existing in an alternative possible world. From this it may be concluded that should Vremya travel back to 1066 and witness the alteration of events there effected by a traveller called Chronos, then at least three alternative possible worlds have been realised. One is this world -- W -- from which both travellers initiated their journeys; one would contain Chronos alone -- W1; and one would contain another modal part of Chronos and the Vremya who left W -- W2. This in turn raises a problem for determinism, for Vremya can no more affect a possible world she did not, in fact, enter, than she can affect the past of this one. She cannot join Chronos in W1 unless she arrives with him at its inception, and if she does enter at that point then, because the creation of that world lies at a moment in the past of the world from which they both began their journeys, the time traveller's freedom to enter or not is once again denied. If it is a fact that he was in W1 in 1066, then because the passage of time for W1 must agree with that of W if time travel between the two is to occur (otherwise the traveller will fail to travel backwards in time at all, or fail to travel back to 1066, see above) it follows that, as with this world, W1 is presently nearly a

thousand years beyond that date, and therefore the time traveller's intervention lies in that world's past and cannot be changed⁷, even though the invention of the machine that will enable that act still lies in the future of this world at the present time (1993). The distinctions made earlier between sufficient and necessary conditions, and experience and occurrence, must still be applied, therefore, if the time traveller's freewill is to be preserved, because ignorance regarding whether or not a time traveller has entered an alternative possible world in the past does not imply freedom.

The problems raised above are further compounded by complications stemming from possible worlds theories. What is the ontological status of possible worlds? Do they exist indexically, independent of the intrusions of time travellers who may visit them, but are not the architects of their existence, or do they depend entirely on the paradoxical activities of time travellers for their creation? If the former, then determinism is preserved as argued above. If the latter, it seems extravagant to suggest that the simple utterance of an anachronism can create a universe, and simpler to deny the possibility of time travel altogether.

The system of modal parts also requires closer examination. How does one determine one's modal part in

7. Otherwise problems arise regarding the ontological origins of the alternative worlds (see below).

another universe? Lewis's counterpart theory is a likely candidate, but there seems no clearly defined means of ascertaining which person in a given alternative universe is the closest to an individual in this universe. In his article 'Counterpart Theory and Quantified Modal Logic' (1968) Lewis writes that

Your counterparts resemble you closely in content and context in important respects. They resemble you more closely than do the other things in their worlds. But they are not really you...The counterpart relation is a relation of similarity.

Lewis, 1968, p. 114-115.

In other words, an object α in World 1 is the counterpart of an object β in World 2 iff there is no object in World 1 that more closely resembles β in World 2 than α is. However, as Graeme Forbes points out (*The Metaphysics of Modality*, 1985),

It is consistent with this criterion that x in [World 1] has more than one counterpart in [World 2] since two or more objects in [World 2] may be equally similar, as they are there, to x as it is in [World 1], although more similar than all the other objects in

[World 2].

Forbes, 1985, p. 58.

Which, then, is the closer counterpart between the one that thinks the same and the one that looks the same, when a combination of the two is unavailable? Is it the one with blue eyes, or the one with green (when in this world the person in question has brown eyes)? In the case of Chronos' journey to 1066, because the origins of W1 lie in this world -- its separate status as an alternative world being achieved only at the moment of the arrival of Chronos -- and the only difference between the two worlds at the moment of branching is the initial and continuing existence of the traveller in W1, such problems may well not arise. However, let it be supposed that Chronos moves forwards in time using his machine. Since this would no more engender logical contradiction than a similar journey into the future of this world, Chronos would remain in W1 (there being no cause for his relocation). Suppose he then encounters a man in his youth who bears a disturbing similarity to Adolf Hitler in both looks and mentality. Should Chronos assume the worst and attempt to destroy the alternative Hitler, or wait in the knowledge that history has been affected already (by his own arrival) and the chances of the same outcome from two different origins are very slim? The moral implications arising from this problem of identity are considerable. Should his judgement -- based on the assumption that history

has already been affected -- prove erroneous, he can only go back in time and enter another world (W3) in which he may be faced with a similar dilemma; he cannot correct his mistake in W1.

On a more fundamental level, there remains the possibility that Chronos could enter a world in which there exists one of his own modal parts. While identity might prove difficult to determine visually, the in principle possibility of examining the causal history of each modal part would be sufficient to determine which came from which world, unless there existed exceptional circumstances. Such circumstances would require that both versions came in an identical manner from other worlds resembling each other in all essential details. Yet even under these conditions one would arrive before the other or, if they arrived simultaneously, each would occupy a slightly different spatial position, and consequently it would be possible (in theory) to distinguish between the two. It is also a matter for debate whether or not the modal parts of a traveller would merge when meeting in one possible world, but this does highlight another problem.

As has already been shown throughout this thesis, although time travel has yet to be realised (if, indeed, it can be) it is possible to argue coherently about the logical consequences in a thought experiment generated world in which such activity occurs. This is because certain parameters must be adhered to if the concept is to be

discussed at all. For example, a world in which time travel can occur because there are no systematic and/or predictable (if only in small part) laws of physics would be incomprehensible and irrelevant to persons from a world as highly ordered on the macroscopic scale as this one. As the purpose of this thesis is to determine whether or not a time machine could operate in this world, the physical and logical laws that obtain here (as presently understood) may be invoked as a basis for argument. Once the discussion encompasses the realm of possible worlds, however, the question arises as to whether or not they are subject to these same laws. If they are not, any conclusions drawn may be easily undermined by the denial of any agreed physical structure existing between this world and the one cited.

Possible worlds, by definition, should contain within their number members whose physical and/or logical structure does not agree with that of this world (provided internal coherence is preserved). Critics may argue that no further discussion is possible, because the traveller may enter a world that differs so vastly from this one that its very nature invalidates the relevance of any conclusions drawn; while this is certainly true of a system of possible worlds in which there exist no spatio-temporal relations, it is arguable whether or not this proposal retains its force when applied to a branching system of possible worlds. The traveller will enter a world as a result of his attempt to alter the past, and consequently the world entered should

reflect this. Thus an attempt to introduce a machine gun to the Battle of Hastings will be met by relocation in a world in which a machine gun and its operator magically (to the local inhabitants) appeared, and not relocation to a world in which gravity has been reversed. This argument necessarily extrapolates from present experience. Although quantum physics claims anything is possible, probability theory prevents the more outlandish from occurring on the macroscopic scale. Similarly, although there could be a world in which gravity was suddenly reversed on the Earth in 1066, it is improbable that the act of introducing a machine gun would lead to the traveller's relocation in such a world. Yet the fact remains that there is no sound basis for argument. To what extent an alternative possible world can be guaranteed to agree in all fundamental respects with that vacated by the traveller, depends on the causal relations existing between those worlds. If the link is akin to that which exists from one moment to the next within one world, the probabilities governing that world may be applied with equal justification to another. If not, the increasing number of assumptions and hypotheses required to support the argument may be such as to render it meaningless. Once again, the nature of this connection depends on causal relations, and so further discussion must be reserved until the next chapter. There does, however, remain one aspect of possible worlds theory that may be analysed in more depth: should they be invoked, how would one then prove the

existence of time travel?

Section 6

Proving Inter-World Time Travel

In any attempt to prove the success, or otherwise, of an expedition involving time travel within possible worlds, three different perspectives must be borne in mind: that of the time traveller; that of the inhabitants of the world in which the journey began; and that of the inhabitants of the world in which the journey ended. Each has its own unique view of events, and none is free from complications.

When considering the pattern of events as witnessed by those left in the laboratory after Chronos' departure, there arise several possible explanations for his disappearance.

(1) He has been successful in his attempt to travel into the past, and that has necessitated his movement into an alternative possible world. (2) He has been unsuccessful, and his ship has been vaporised. (3) He has moved into an alternative world but he has not moved backwards in time. (4) He has moved in space but not in time. Of these, 3 and 4 may be dismissed by reasoning and empirical evidence respectively. In the case of 4, sensing devices, radio signalling, and subsequent investigation of any sign indicating the continued existence of the machine or its occupant within the confines of this solar system⁸ should

8. Or whatever spatial distance the machine is capable of achieving between the moment of take-off and that at which contact is lost.

prove sufficient to forestall such an eventuality. As to the third explanation, it is reasonable to assume that if the traveller has not moved in time, he is no more likely to move into an alternative universe than any other human being at any other moment in their lives. For without time travel there is no potential for paradox, and therefore whatever he does -- including the total destruction of the launch site -- may be included as part of the history of this world and those objects contained within it.

In option 2, complications arise only if there are no detectable pieces left of the time machine to indicate its destruction. Around the launch site sensors could be installed that are tuned to the molecular structure of the machine and its occupant's DNA: but once a position has been established outside Earth's atmosphere -- in order that the movement of the planet around the cosmos since the date in question may be accommodated -- the difference between total annihilation and the natural effects of attempting to violate 'time's arrow' may prove difficult to distinguish. It would be impossible to receive signals from a transmitter aboard the machine after its time (as opposed to space) departure, because any signals would already have been sent long before during a successful journey into the past. Consequently, lack of success in the receipt of such messages (if they are still around to be received) might cause the traveller to assume the failure of his venture before any attempt is made, and a self verifying situation

may be created. From this it follows that because the message has not been received in this world, the moment a traveller attempted to send such a message he would enter an alternative world. As a result, not only would there be no proof of the traveller's success, but Chronos could never travel back to the closest possible world to this one in 1066, only to the 1066 of the world he first entered as a result of his initial transmission, and in the next chapter I will question the possibility of his doing even this.

Finally there remains the possibility that the hoped-for result is achieved; but how could this be verified? Those continuing to exist in the world Chronos leaves behind will not experience any effects resulting from his activities in the past; therefore the only direct method of verification would depend on the return of the same modal part (but a later person-stage) at some point in the future. However, the probability of this occurring is extremely remote. This is because in order for him to return, the world Chronos inhabits as a result of his actions, and the world he left, must grow sufficiently similar that the correct temporal movement by the time traveller will enable him to 'hop across the gap' and reappear in the world where his initial journey began. The two worlds cannot simply coincide in the future, because this would require that a person who did not exist in one world (Chronos) suddenly appear without the aid of his time machine at the moment of unification, and two worlds that differ by even so much as

the position of one molecule, much less the physical presence of an entire human being, could not merge to become one. Nor can this be used to support the claim that two modal parts of Chronos would merge when meeting in one world, because under such circumstances one person -- the result of this merging -- would contain within his memory two accounts of events up to the moment of merging that could be slightly or vastly different, and either way would be contradictory. Even when considering inanimate objects, contradictory causal descriptions of the events leading up to the moment of unification cannot be held within the past history of one object. From this it appears that the traveller must in some way determine the moment at which the two worlds are closest, and then make a brief journey into the past in an attempt to return to his original world. The chances against his predicting precisely the activity in which he must engage in order to successfully complete his journey are enormous, and therefore the chances of his return are remote. In fact, provided he makes the attempt at a moment subsequent to that of his initial departure (recall that time must agree across worlds that are accessible under this system), he is as likely to re-enter a world after the moment of his departure by the performance of an act that is totally outrageous in the world he is inhabiting, as by attempting a slight modification at one minute past that instant. If his initial journey began at 12.00 on 29 May, 2050 in World 1, and at 12.05, 29 May 2050 in World 2, World

1 and World 2 are as physically close as they can be with a traveller existing in one and not the other, he is as likely to return to World 1 by using his machine to travel back to 12.00.1 and picking up a piece of paper, as he is if he waits until 3000 and then travels back to 2090 in order to murder an important diplomat.

Another means of verifying Chronos' activities would depend on a time traveller from an alternative world -- but not any previously occupied by Chronos, for reasons that will be explained in the next chapter -- entering this one. If this traveller's time machine functions on the same principle as that in which Chronos left, then by means of inductive reasoning (with all its associated problems) the scientists could argue consistently for the success of their venture.

Consideration must now be given to the perspective of those occupying the world Chronos enters: would they be better placed to appreciate his achievement? It seems likely that once Chronos has affected the past -- especially in a manner as significant as the outcome of a major battle -- he will no longer be in a position to predict subsequent events with total accuracy, because they will differ from those with which he is familiar. While it is conceivable that the resemblance between certain events that Chronos remembers occurring in the world he departed from and those happening around him in W2 would be sufficient to enable him to provide more or less accurate predictions regarding their

outcome, as each bad prognostication is acted upon and so prevented, fewer events will resemble those with which Chronos is familiar, and consequently his accuracy will be diminished until he is as incapable of precisely predicting the future as those around him. Once this stage has been reached there will no longer remain any tangible evidence of his futuristic origins. Indeed, since he did not travel from the future of that world but rather from this one, he could not honestly claim to be from the future relative to them, only a possible future, the proof for whose existence depends on the assumption that the traveller is telling the truth, which in turn generates a circular argument. His original success could be attributed to luck, his subsequent failure to being human. He could demonstrate an ability to meet people at a pre-arranged time and place in the future, having aged no more than a few minutes against their years, but while this might be considered satisfactory evidence of a journey into the future it would not endorse his claim to movement into the past.

Finally, there remains the perspective of the time traveller himself. He would appear to be in the best position to validate his claims, yet he may, in fact, be no better equipped than those left behind in the laboratory. Chronos has left one world of which he has memories, and has entered another world that differs from the former in certain respects, but at that particular point generally resembles the place called Battle in Sussex as it would have

appeared in 1066 AD. However, it is unlikely that he will have physical proof, beyond these basic indicators, that he has moved both backwards in time and between worlds, and there remains the possibility that he has moved solely between worlds. The only reason for doubting this is the same as that considered by those in the laboratory, i.e. there would be no reason for a person to move between worlds unless they attempted to alter the past. Yet the powers of his machine may be more or less than anticipated. Thus it is reason, and not physical fact, that may be the only indicator of a success that is fully appreciated by the time traveller alone.

This chapter has considered the problems of freewill and determinism both for the time traveller and for those in the world he occupies. In an effort to preserve freedom of will the importance of distinguishing between the number of *experiences* possible of any given event and the one *occurrence* of that event has been emphasised, as has the application of necessary and sufficient conditions to the causes of the time traveller's behaviour. Finally, in order to dissolve intuitive objections to the above arguments, a system of branching possible worlds was introduced and analysed. In the course of that analysis it was argued that the system contained considerable internal problems, the attempted resolution of which would be reserved until all other avenues of investigation had been exhausted. These avenues will be examined more thoroughly in the next

chapter, that is concerned with the commonest attacks levelled against the possibility of time travel within one world: those that originate within the field of causality.

Chapter 5

Causation

In the definition of time travel that was provided at the beginning of this study it was claimed that the popular definition includes the ability of the time traveller to causally interact with objects and events in the past, and this has ensured the high profile of problems connected with causality. In addition, the identity criterion for such a person has been described as being necessarily dependent on the causal continuity and connectedness of person-stages (excepting deviant causal chains) with respect to the personal time frame. Time travel and causality are therefore intimately connected in the popular system, and the examination of that relationship and the complications arising from it will be the concern of the following pages. Before any discussion can begin, however, the assumptions that underpin the causal relations to be examined must be clearly delineated.

It will be assumed that causal relations may be transitive. In other words, if event A causes event B, and event B causes event C, then event A is a causal ancestor of event C. Furthermore, if A is a necessary condition of B, and B a necessary condition of C, then A is a necessary condition of C. This assumption is so rudimentary that we often neglect the intervening stages and simply report that A caused C. Thus, the flicking of a switch is said to cause the bulb to give off light, when a full description of

events would require the mention of circuits, connections, filaments, and friction. To deny the transitivity of causal relations is to deny a major tenet of human existence and scientific experimentation, yet our assumption of this transitivity will prove of vital importance to later discussions.

This chapter will be particularly concerned with the following causal considerations (in order): those of backward causation; closed causal (time-like) chains and world lines; causality violation and logical contradiction. From this analysis will be determined the logical possibility, as well as the probability, of repeated, non-accidental, backward temporal movement within one possible world. Should the results prove unsatisfactory, I will consider some alternative models, and I will examine whether these are also subject to the logical problems that have been raised.

Section 1

Backward Causation

The spontaneous human reaction to the possibility of a reversal of the causal direction is normally negative. The reason for this may well lie in a deep-rooted association between the temporal direction and the causal one. For example, when observing the widely scattered pieces of a wine glass lying on the floor beneath a table upon which stand similar glasses, the assumption is made that this is

the culmination of a series of events: the glass was originally standing upon the high table, whence it was knocked to the floor and consequently shattered with such force that the pieces flew some distance before coming to rest in their present positions. It is not usual to imagine that in the next few minutes the pieces will gather sufficient energy from their surroundings to fly together to form a complete glass that will then rise from the floor and alight upon the table intact. Even the sentence structure in this example reflects human preference. The glass is described as being 'originally' intact upon the table, and as a 'consequence' of being struck directly or indirectly, it falls to the ground to smash with such force that its pieces are widely scattered. Both temporal and causal phrases are linked together, with the causes being associated with the earliest moments, and the effects associated with the latest moments. Yet this intuitive sense of temporal and causal direction is not always supported by modern science. Once the analysis is centred on the behaviour of the individual particles that compose the glass, there is found to be no reason why the opposite series of events -- that the glass should begin upon the floor in pieces and end intact upon the table -- should not occur; in fact, the description of these events by a particle physicist could contain a temporal indicator that is totally indifferent as to its direction. In philosophy it has also been argued, most notably by Michael Dummett in his

article 'Can an Effect Precede its Cause?', that while we 'feel a strong *a priori* objection' to the idea that the occurrence of an earlier event might be explained by the occurrence of a later one, nevertheless it is not impossible. The reason for the objection lies in the fact that, if it were possible, then it might also be possible to act with the intention of bringing about a past event, i.e. to act in such a way that a past event should have occurred. This, in its turn, appears plainly nonsensical; and yet, as Dummett argues at the end of his article, if we found that - - to take his example -- the utterance of the word 'click' before the opening of a letter ensured that it was not a bill, and there was no other explanation for the non-arrival/sending of a bill other than this, and only on those occasions when we forgot to say 'click' before opening a letter would it prove to be a bill, then 'it could not but be rational to believe in it and so make use of it' (Dummett, 1978, p. 332).

Yet, despite the claims of particle physics and some philosophies, probability, human intuition, and day-to-day experience favour one temporal and one causal direction: the 'arrow of time' points from the past to the future, and causes always precede their effects (sometimes via a series of intermediary causes). If particle physics is abandoned in favour of an examination of the macroscopic general view, rather than the microscopic particular one, there is revealed a study that is not only more appropriate when

considering a human being and a machine built to carry him, but that also contains a temporal indicator with a marked preference for one temporal direction. Entropy is not indifferent to the direction of the temporal arrow, but instead increases with the passage of time in keeping with the temporally asymmetrical Second Law of Thermodynamics¹. If the description of a time traveller into the past appears to invoke backward causation, and thereby violates common experience, probabilistic preference, and our intuitions, there would seem good reason to find some alternative explanation.

A brief analysis of every description of time travel into the past would appear indistinguishable from that of an example of backward causation: i.e., the traveller steps into his machine and begins his journey at a moment in the future relative to the moment of his arrival. For example, Chronos enters his machine in the year 2000, flips a lever, and, as a direct or indirect result of this activity, appears in the year 1066, nine hundred and thirty-four years before his departure. No one would wish to deny that the operation of the lever was a necessary cause of his appearance in 1066 inside a time machine, because that is the function of such a machine, and if the appropriate operation of levers etc. does not cause the operator to be re-located at some earlier temporal instant, then the machine does not work as it should and there can be no

1. See P. Coveney and R. Highfield, *'The Arrow of Time'*, pp. 32-33 et passim.

guarantee that the intended place and time of arrival will be achieved on every occasion of operation. Although the possibility exists that the operation of the levers is unnecessary, and the time traveller will always arrive at his intended destination by pure coincidence, it may be ruled out for the purposes of the present study because the assumption is being made that time travel is taking place as a direct result of the traveller's programming activities. Accepting, therefore, that the operation of the lever at time t_1 is a necessary condition of the arrival of the time machine at time t_{-1} , must it be assumed that there has been a case of backward causation, or can an alternative explanation ease any residual sense of discomfort?

In fact there are (at least²) two other ways of explaining the series of events described above, both of which nullify the need for backward causation. They are also more accurate descriptions of the sequence of events from the perspective of the time traveller, and are therefore to be preferred because -- as has already been indicated in the last chapter -- only Chronos can have any physical appreciation of the consequences of his temporal activities. Unfortunately, each of these descriptions contains serious consequences for the possibility of time travel under our present description.

2. Most other time travelling descriptions can be reduced to these two choices. Mental time travel (such as that envisaged in Jack Finney's Time and Again or in the film Somewhere in Time) does not correspond to either method, but such temporal relocations of the body through thought require a great many more assumptions about the nature of time and thought than I feel can be justified in this study.

The first alternative has already been encountered in Chapter 2. There I considered one of the most fundamental attacks that has been directed against time travel -- the apparent contradiction in affirming that such a person has travelled both five minutes and one hundred years. The solution was to assume more than one temporal reference. By this means the answer is then qualified by the addition that he has aged five minutes relative to his personal time frame, while travelling one hundred years into the past relative to the external time frame. This solves many problems -- not least the one presently under discussion -- because time travel (appearances to the contrary notwithstanding) does not involve backward causation *from the time traveller's point of view*. Chronos experiences the passage of events in a standard progression, with the flicking of the lever coming before the moment of arrival in 1066 according to the personal time frame. From Chronos' perspective, therefore, there is no difficulty in explaining both the remote and the immediate causes of a given event and the relations between them, because the ordering of causal activity inside the machine is directed in the normal way relative to him. It is only when the activities of Chronos are examined from the perspective of an observer who is at rest with respect to the external time frame that the appearance of backward causation arises.

In Fig. 5.1 the first appearance of the traveller is at point A, while the cause of that appearance does not become

evident until point B. Due to the fact that the ordering of temporal experience for the external observer is identical to that of the history of the planet, and he has no sense of the passage of events as experienced by the backward-travelling Chronos, he must assume one of the following: (A) that the arrival of Chronos in 1066 was a spontaneous creation with no antecedent or consequent causal explanation; (B) that the ordering of events is such that the spontaneous creation of Chronos in 1066 was the remote cause of his setting the co-ordinates (both temporal and physical) and pressing the lever that caused his annihilation in 2000 AD; (C) that there has been an incidence of backward causation, such that the appearance of a person called Chronos in 1066 was/will be caused by the activities of a person in 2000 AD. In this last scenario the existence of a causal relation does not necessarily imply the existence of an identity relation; furthermore, none of the above descriptions includes a reference to time travel into the past. For these reasons they all fail to describe the actual state of affairs that has been revealed by an analysis of the causal relations through the personal time frame. This, then, demonstrates that there is scope for a more considered analysis of the importance of time frames to the study of causal relations arising from time travel.

D.H. Mellor (1981) argues that time travel necessarily involves backward causation and closed causal chains³, and

3. *There may be some ambiguity here. There is no question that Mellor associates time*

his analysis depends on the importance of the external perspective. In his book, *Real Time*, he attempts to prove the impossibility of backward causation by analysing a thought experiment that is similar in structure to Dummett's dancing tribal chief. Mellor gives the example of fires whose ignition at time t_0 is said to depend on the application of matches at time t_2 . Yet a time traveller could not fulfil the activity Mellor describes. Whether or not the fire (or the match) is lit in the future (t_2) and then transported via the time machine into the past (t_0) does not detract from the fact that the sequence of events according to the personal time line of the fire requires that the match be applied before ignition occurs. Genuine backward causation would demand that the match be applied after the ignition of the fire relative to the personal time frame.

The introduction of the closed causal loop stems from Mellor's claim that the departure of a scarf-wearing Dr Who in his 'Tardis' in 1984 is the cause of his arrival wearing that same scarf in 1884, and his arrival in 1884 will have consequences for his departure in 1984. These consequences could be significant and apparent -- such as a report in *The London Illustrated*, revealing the exact moment of his

travel with backward causation and closed causal chains, but whereas I take it that he is arguing against backward causation (hence his inclusion at this stage in my argument), Riggs (1991) claims that Mellor's argument hinges on the contradictory nature of closed causal loops. This does not affect my argument, however, because here I am taking issue with Mellor's association of time travel and backward causation (either directly or via closed causal chains).

arrival and his attire, that is subsequently read by Dr Who and shapes his decisions regarding these factors -- but, as was argued in the previous chapter, the fact that the traveller's activities in the external past are known to him before he begins his journey need not necessarily shape his future personal behaviour. The past cannot be changed, and therefore his awareness of the nature of events related to his behaviour that lie in the external past and his personal future makes no difference to their causal effect on him.

Although the personal/external distinction inhibits any reference to backward causation during time travelling activities according to the popular definition, there is another means by which Mellor's arguments against time travel might be circumvented that depends on the nature of the physical method employed by the traveller in his journeys to the past. It hinges on the Gödelian interpretation of Einstein's General Theory of Relativity; this alone makes it worthy of study, but it also raises issues that will prove useful to later discussions.

According to Gödel's cylindrical interpretation of space-time, there might be worlds in which

...by making a round trip on a rocket ship in a sufficiently wide curve, it is possible...to travel into any region of the past, present, and future, and back again, exactly as it is possible in other worlds

to travel to distant parts of space.

Gödel, 1949, p. 560.

Using this method, Chronos' temporal movements would always entail travel into the local future even though, from a global perspective, he would travel into the past, and therefore there would be no local violation of the causal direction and no need for an independent personal time frame. Throughout any journey into the past, the time direction and the causal direction would remain positive both inside and outside the machine. This can be better understood using Fig. 5.2, which is based on that used in Horwich, 1987 (p. 113). Here, due to the combination of a cylindrical space-time model and two space-time dimensions lying at 90° to one another, the traveller eventually comes full circle, finding himself at a moment in the past relative to his moment of departure, even though he has travelled consistently into the future relative to the light cones of each space-time dimension in turn.

While Gödel's description obviates the need for the personal/external time distinction to resolve the problems of backward causation, it does not contradict the existence of those time frames, leaving the way open to their use in resolving other problems that the Gödelian model might not accommodate. Yet Gödel himself doubted the practicality of his model on logical grounds, and in order to forestall complaints that his description must be incorrect because it

would enable bilking experiments he introduced a physical limitation.

This and similar contradictions, however, in order to prove the impossibility of the worlds under consideration, presuppose the actual feasibility of the journey into one's own past. But the velocities which would be necessary in order to complete the voyage in a reasonable length of time are far beyond everything that can be expected ever to become a practical possibility.

Ibid., p. 561.

In making this claim Gödel reveals himself to have committed what may be termed the 'super-time' fallacy. This is the same as the error, highlighted in the previous chapter, that led to the introduction of the experience/occurrence distinction, and it is common to time travel thought experiments. The origins of the error, and the causal continuity and connectedness on which it depends, are the reasons for its introduction at this point, but while its relevance to alternative space-time descriptions explains its presence in this section, it is necessary for some consideration to be given to closed causal chains before the full implications of Gödel's words may be understood. This will be the subject of the following pages.

Section 2

Causal Chains⁴: What Are They?

A distinction can be drawn between closed and open causal chains, and between closed and open world lines. An open world line represents a person's path through space-time: he is born, lives, and dies. The temporal arrow expressed in the world line is future-directed with respect to both the external and personal time frames, it is continuous, and it has a beginning and an end. A closed world line, on the other hand, represents an object that is the cause of its own initial and continuing existence. Here, a series of person- or object-stages is so arranged through time that each stage is both the ancestor and the descendant of every other stage, including itself, and consequently each stage depends on the existence of every stage -- including those that lie after it relative to the external time frame -- for its own existence. No one stage has personal temporal precedence over any other, and none may be discarded without profound consequences for the existence of the entire closed world line.

An open causal chain can be used to describe the events surrounding a steam train's operation. Coal is shovelled into the coal-hole, and this heats the water that turns to steam: this drives the pistons, that turn the wheels, that

4. Many refer to causal or time-like loops. While this describes their appearance on space-time diagrams, it does not evoke their physical structure. I have therefore deemed the word 'chain' more appropriate to the circumstances, although the word 'loop' may be substituted by the reader if it is preferred.

make the train move along the track. Once again there is a beginning and an end, and the flow of causal relations is -- as with the direction of the temporal arrow in the example of the open world line -- future-directed for both temporal reference frames, emphasising the strong association that exists between time and causality. On a larger scale, a similar causal chain could represent the entire history of the steam train, indicating that world lines are simply a special case of causal chains. And just as a closed world line depends on time travel, so too does a closed causal chain. For example: imagine that Chronos steps into his time machine and travels one hundred years into the past. At the moment of his arrival he makes love to a girl who has a child. The child grows up, gets married, and in due course has a son who is named Chronos, and it is this child who travels into the past and makes love to a woman who proves to be his own grandmother. A more involved version of this story has been suggested by Robert A. Heinlein in his short story *All You Zombies*. There, the same individual -- by means of a sex change -- succeeds in becoming the sole member of what appears to be a four-member family, being his own mother, father, daughter, and son⁵. Closed causal chains may be of a very short duration, or they may be spread over many years or even centuries, with each step being the remote rather than the almost immediate causal ancestor of

5. It is interesting to note that, according to the arguments of St Aquinas, Heinlein's 'unmarried mother' is God!

itself. Their generation is as a direct result of time travelling activities, and, as before, they do not necessarily have any causal dependence on anything outside the chain. Since world lines have been shown to be special cases of causal chains, the phrase 'causal chain' will henceforth represent both terms.

If a closed causal chain is entirely interdependent, the question remains as to how it can ever begin. No one stage can come into existence before any other stage; consequently, in order to exist at all as a causally integrated whole, every part of the chain must come into existence 'simultaneously'. This word is somewhat ambiguous, however, for what interpretation can be placed on the concept of simultaneity when stages in the loop are in the past or the future relative to other stages, according to the external time frame? Even if this problem could be overcome -- perhaps by the introduction of another time frame -- the problem of causal interaction remains. How can each stage be causally associated with every other stage when there is, by definition, no causal priority? Without causal relations between person-stages, the identity criterion that was cited in the third chapter would be unfulfilled, and consequently none of the problems associated with a time traveller in the popular image would arise, because it would not be one being who existed throughout the duration of the journeys into the past and the future.

What if the concept of simultaneity were abandoned in favour of a linear development of the events that are said to form a closed causal chain, developing from the earliest moments of the chain's existence with respect to the external time frame? This situation is represented in Fig.

5.3. If one ignores the information on causal relations that is provided by the personal time frame, and instead follows the pattern of events according to the ordering imposed by the external time frame, it can be seen that point A is first: it exists before the moment of the (so-called) closed causal chain's completion and -- because the events that occupy the future relative to any given moment are not to be interpreted as coming into existence either before or at the same time as events lying in the past on this diagram -- events at A cannot be dependent for their existence on those at either B or C. The representative graph might be interpreted by an observer at B in one of two ways.

- 1) An object is spontaneously created travelling backwards in time at point B1. At the moment of its arrival at point A, the object stops and takes up a normal temporal direction until point B2. As B2 lies in the present, the object's future activities remain unknown. This is unsatisfactory because at point A, point B, and those events and stages associated with it, will lie in the future, and therefore they will not exist. The observer in this example has illegitimately placed himself at a moment in the future, relative to the earliest moments in the order of events, and

this has resulted in an inaccurate interpretation -- albeit one whose simplicity and convenience are extremely seductive. This leaves the second alternative.

2) Two objects are spontaneously created at point A. One moves off in the forward temporal direction to point B2, while the other moves toward point B1, all the while growing younger⁶. At any given point, the future activities of the beings remain unknown.

In interpretation (2) there is no causal association between the object at B1 and the object at B2 to indicate any mutual dependence, because the future of the objects is unrealised. They are two spontaneous creations advancing through time, with one revealing a reversed personal temporal indicator. In each case the stages already in existence have no dependence on future events, because otherwise they could not exist. The future in this example is an unknown quantity -- not because we have not experienced it, but because there is nothing to experience. Consequently, any apparent causal association that may one day seem to exist will be at best coincidental, and at worst illusory in the best traditions of Humean empiricism. To guarantee the existence of a closed causal chain, it is therefore necessary that two aspects of time -- the past and the future (aspects whose ontological status has been traditionally a source of much discussion) -- must be

6. An example of this interpretation has already been discussed in Chapter 3, where Robert Weingard's article On Travelling Backwards in Time was shown to be an unacceptable description of the popular system of time travel.

granted equal status with the present and, in some sense, co-exist. Therefore, just as it is the case that for time travel to occur at all the future must, at least from the point of view of the time traveller, exist, so also closed causal chains require that the future exists. The similarities between the needs of closed causal chains and time travel may not be coincidental, but the true nature of their association has yet to be revealed.

One method by which closed causal chains might be achieved has already been mentioned. Kurt Gödel's cylindrical universe model, by its very nature, endorses the creation of closed causal chains. Yet Gödel also claimed that such a system would, in theory, permit the occurrence of mutually contradictory events, and it was stated that this indicated that he had succumbed to what was termed the 'super-time' fallacy. The claim that physical limitations would prevent such occurrences does not account for the fact that closed causal chains -- and not just closed, or nearly closed, world lines -- can also generate contradictions as profound as those of which Gödel spoke, e.g. the inadvertent destruction of the first amoeba by a time traveller. This problem can now be investigated.

Super-time is an intuitively appealing concept that is a vital aspect of the so-called 'Myth of Passage', and as such it is a popular misconception of western thought. Graham Nerlich, in his article *Can Time Be Finite*, discusses Gödel's claims regarding the possibility of contradictions

arising from the latter's space-time model.

We add to a perfectly coherent picture of an almost-closed time-like curve the idea of a unique, ontologically distinguished time, the present...The events which make up...x's life are like a circular array of lights, each being lit only when it is touched by the passing nimbus of reality, the present. As the present passes (in super-time) round the circular array of events of cosmic time it comes back to an event a second time (super-time) and the light is lit again...Without these dubious assumptions nothing lends even an air of intelligibility to any claim that x is at 1970 at two times. The ease with which we follow Gödel's footsteps shows how ingratiating those assumptions are, provided only that we keep them unformulated.

Nerlich, 1981, p. 233.

As has already been made clear in the preceding chapter, the events in external time only occur once, and so Gödel's suggestion that the traveller can in some way change the past is nonsense. Yet the image of a time traveller greeting his earlier self and committing an act he knows did not occur is, as Nerlich points out, easy to follow as a direct consequence of our intuitive belief in the 'Myth of Passage'. Nerlich claims that the image is acceptable only so long as its status remains unformulated, and so some

consideration should be given to the questions that might be asked when attempting to provide such a formulation.

How is super-time related to the external time frame? If it is defined as something that contains every event in external time at one and the same instant, to what extent may it be called time at all? If the sum total of events in external time are co-present in a super-time that contains no additional events that are peculiar to super-time alone, then the duration of super-time would be as brief as the shortest possible interval of external time (however that is to be defined: recall Newton-Smith's comments on the nature of temporal structure in Chapter 3). If this is not the case, how are events to be temporally divided? Is every event in the history of the planet to be granted an equal temporal value, so that the Battle of Ypres will occupy as much super-time as that required by an athlete to break the four-minute mile? If this were the case super-time would appear to lack duration, for how long does it take actually to win a race or a battle? It is tempting to imagine all the events of external time laid out linearly before a person existing in super-time, or, like the Boethian cart-wheel, surrounding a hub from which we gaze across external time. In imagining this picture, however, we introduce an observer, and super-time becomes more than the instant of indeterminate duration required in order that an infinite number of events may simultaneously co-exist; it is also the passage of time required for the observer to observe and to

exist⁷. Alternatively, every event in external time could have infinite duration in super-time. In this way the problem of the indeterminate minimal duration of any given event is overcome, and an observer could experience any given instant in the past, present, or future of external time in conjunction with any other moment: but then mutually contradictory states -- such as the non-existence and existence of the planet Earth -- would co-exist, and if such events were not distinguished by their temporal positions, then the question arises as to how this situation would be possible. Suppose instead that events occurring in external time have their temporal position indicated in super-time by their spatial position. Thus a Boethian interpretation has been re-introduced, with all the events contained within it having infinite duration in super-time. Such an interpretation would require a more detailed examination of the relationship between external time and super-time that permits a spatial interpretation of temporal events, and that is outside the purview of this thesis. Even the brief analysis provided here is sufficient to reveal a considerable number of problems associated with the concept of super-time. It is therefore unsuitable to the problem of explaining the creation of closed causal chains, to which this study now returns.

A brief resumé of the problems encountered so far may

7. The introduction of God as the observer brings with it too many theological implications to justify such a 'solution' to the problem, and consequently I have not attempted to include such a suggestion in this analysis.

be of some assistance.

1) No person- (or object-) stage in a closed causal chain can be causally anterior to any other one, because the whole is interdependent, with each stage both preceding and following all others in the chain, including itself.

Consequently, the existence of any one stage requires the existence of all the others that constitute the structure. Since none have causal priority, all stages must come into being simultaneously.

2) A closed causal chain exists across an interval of external time; consequently, instantaneous creation relative to that reference frame is not possible.

3) The concept of super-time is a more complex solution to the problem of closed causal chains than can be reasonably justified, and premise (2) prevents appeals to the external time frame. There remains one reference frame not so far considered: that of personal time.

4) Some causal dependency between stages is required to ensure that the appearance of an organised causal association on the level of external time is representative of a genuine association on the level of personal time. This will preserve the necessary identity criterion for persons or objects, as well as genuine causal interaction (as opposed to coincidence) for actions and events.

How may all these points be reconciled? Let it be supposed that the causal chain comes into existence simultaneously relative to a moment in the personal time

frame (the only temporal reference remaining). This would seem to pose a problem for the identity criterion, because the creation of person-stages as described above obviates the possibility of a causal continuity and connectedness between those stages. How can each stage be causally related to those preceding and succeeding it in personal time when every stage -- relative to that reference frame -- is co-temporal? Even were a system of causal relations introduced which ensured that the creation of any one stage in a closed causal chain instantly caused the creation of every other stage associated with it, and the absence of any given stage prevented the creation of every other one, a problem of meaning remains. What does it actually mean to say that every stage in a closed causal chain has been created simultaneously relative to the personal time frame, while the whole chain is extended through the external time frame? When the traveller is journeying into the past within his time machine this interpretation would seem to imply that his journey would be instantaneous, because the duration of the journey within the machine is measured according to the personal time frame, and every person-stage has been created simultaneously relative to that reference. Consequently, the journey itself will be instantaneous according to those measurements. Alternatively, each person-stage could be imagined as coming into existence at the same instant relative to the personal time frame, while their physical ordering and their duration would be determined relative to

the external time frame, even during a journey into the past. Even if sense could be made of this last suggestion, the eradication of the external/personal division that it appears to entail not only re-opens the door to the problems of backward causation, it also makes a nonsense of the popular concept (as shown in Chapter 2).

Suppose each stage were causally dependent on those preceding it, but not on those succeeding it, or itself, for its existence. In order that the illusion of a closed causal chain might be preserved under such circumstances, at least one stage would have to be a spontaneous creation whose existence was independent of those stages either side of it. Unfortunately, this still does not resolve the problem. Not only would such a structure fail to fulfil the necessary criteria of a closed causal chain, but the coincidental nature of the independent stage would become suspect when every attempt to generate such a chain by a time traveller was met with such a convenient and specific creation. Furthermore, so long as a causal relation exists such that an event in the future (the departure of the machine) is the cause of an event in the past (the arrival of that machine at a later point relative to the personal time frame), the problem of explaining the necessarily co-temporal nature of events lying at different points relative to the external time frame remains. This is due to the fact that the consequence cannot exist without the cause (if a genuine causal relation is to exist), therefore the existence of the

machine in the past is proof of the necessarily causally anterior occurrence of the moment of departure that lies in the external future. Furthermore, the presence of any cause at a moment in the future relative to its consequence, including any intermediary causes that lie between the moments of departure and arrival, is sufficient to generate the problem. Consequently, no stage in a causal chain that runs from the present (or future) to the past could exist without this problem occurring. The logical solution to this dilemma has proved evasive and, at best, *ad hoc*. It would be far simpler to deny the initial existence of closed causal chains in general or open causal chains running from the future into the past relative to the external time frame. To deny the latter, however, is to deny time travel altogether, and while the previous discussion has revealed conceptual and physical problems associated with the creation of such chains, this is not enough to prove the logical impossibility of time travel as defined. Further examination is essential to determine whether or not time travel requires both of the causal chains that fulfil the above descriptions (open and closed), and should one or both prove indispensable it will then be necessary to examine whether the chain/s are not only conceptually absurd (space travel was once regarded in a similar fashion) but also internally contradictory. If it can then be shown that a prerequisite of time travel is logically contradictory, time travel as defined will have been proved impossible.

Section 3

What Do They Do?

The popularity in academic and science fiction literature of problems arising from closed causal chains has provided considerable variety from which examples may be chosen. An excellent science fiction example already mentioned is Robert A. Heinlein's short story *All You Zombies*. If attention is concentrated solely on those examples arising from purely philosophical studies, rather than those contained in popular literature and films, there is still considerable choice, but since some are merely alternative versions of the same story, I have chosen two that seem to represent most clearly the strands presently under consideration. These are Murray MacBeath's *Who Was Dr Who's Father?* and Graham Nerlich's *Can Time be Finite?* (especially section 5 of that article, entitled 'A problem about time travel in closed time'). I will analyse the problems that arise in these articles jointly with two simpler stories of my own devising. In this way I hope to reveal more clearly the assumptions that underlie closed causal chains, as well as the logical contradictions that all similar time travel stories involve. I will show that closed causal chains, as well as closed world lines, are *always* contradictory, and that any attempt at backward time travel has the potential to generate them. I will then examine methods by which this potential might be nullified,

and attempt to determine both the practical and the logical feasibility of these methods.

The first analysis is based on section 5 of Graham Nerlich's article, *Can Time Be Finite?* There, the author claims that time travel stories leave one with the impression that there is something very amiss, and continues

...I think this impression is correct. I will argue that, if we were to tell a consistent story about X [a time traveller], in full detail, it would be necessary to claim experiences for him which depart drastically from the norms of our temporal experience - - so drastically that many would regard the story as conceptually absurd.

Nerlich, 1981, p. 234.

He then asks the reader to imagine that there be a clock

which has a closed history (all the particles which compose it have closed time-like curves as their world lines) and which X always has with him.

...[S]uppose that X-young enters the time machine and goes on his travels as soon as X-old leaves it and that the clock is handed from X-old to X-young as they pass at the entry. We can suppose this "clock" to be a very crude, simple mechanism. For example, it might be a stick in which X cuts a notch at every mealtime. Now we can certainly say of X, consistently, that he ages,

accrues memories, scars and so forth. Whatever he gets by way of traces he can consistently keep. This is because his world line is not quite closed. But somewhere, somehow, the stick must lose notches if somewhere, somehow, it gains them. For its world line is closed. We can easily see how it could get notched. But how can it get unnotched?

Ibid., pp. 235-236 (his emphasis).

The story contains two closed world lines -- that of the time machine and that of the stick -- but this complication may be simplified because the scratches, knocks, and wear and tear suffered by the time machine during its journeys make that an equally valid but less obvious 'clock'. (Here, the word 'clock' signifies a means of indicating the increasing passage of time and consequent growth of causal history for the object concerned. In this sense, the development of rust makes the Titanic an equally valid clock, because this also indicates the passage of time. The accuracy of the measurement to an outside observer is of no logical importance to this argument.) Just as the stick must lose any notches as it goes backwards in time, so the time machine must lose any scratches or marks it receives that it did not have at the moment of its delivery. Yet even if all the signs of wear and tear were repaired before the time machine was delivered to an earlier person-stage of Chronos this would not be sufficient, because these

are only signs of a more significant difference between the time machine at time t and the same machine at times t_{+1} and t_{-1} : namely, that the machine has grown older. The increased causal history of one party, that indicates a dissimilarity of age with another otherwise identical object, is a genuine difference with profound consequences for backward time travel as defined. It cannot be dismissed as mere 'Cambridge change', because the longer an object exists, the greater its potential effect on other objects. The initial causes of major historical events are often not momentous in themselves. The mere existence at a particular place and time of an otherwise unspectacular object -- such as a rock -- can have momentous consequences. This point will be considered in greater detail later in this chapter, but at this stage (and to better highlight the problems of Nerlich's story) I propose a similar but simplified version.

Imagine Chronos arriving in a time machine and greeting his earlier self. The older Chronos hands over a file that contains explicit instructions for the construction of a time machine, and then he leaves, taking the machine with him. Using the information, the younger Chronos eventually reaches a stage where he is in a position to go back in time to his earlier self and hand on the instructions, thereby completing the loop. At first he considers handing on the file he originally received, but this file is now dog-eared and damaged: there are marks on it that were not there when he received it, and therefore the file at its present age,

with its causal history, is not the file he originally received. In order to become that, the file would have to lose those parts of its causal history that were gained as it grew older in his hands. Would it be possible for the file to grow younger, and the time machine and everything else inside it to continue to grow older while travelling backwards in time?

The answer to this question is important, for if would-be travellers cannot combine these two aspects then the trip will be impossible. If the time machine grows younger as it travels backwards, not only would we not encounter a time machine before the moment of its functional completion, but there could never be any successful time machine. The reason for the former claim lies in the fact that, as the machine grows younger during its backward time journey, it would eventually be required to work at a moment relative to the external time frame, and (with the absence of the personal/external distinction) at a stage in its personal history, that is antecedent to the moment at which it can work -- the machine being incomplete at that point. Consequently, no time machine could visit 1992 or any date previous to this, because no working time machine has yet been invented. The reason for the second claim lies in the fact that the machine was not travelling backwards in time a second before the switch was thrown, and therefore as soon as it begins its travels it must stop again, because in the course of growing younger it will reach the point at which

it had not been turned on. Thus, reversing the temporal sign of the time machine during journeys into the past is not a solution⁸. If the file alone grows younger, however, can it be carried by the machine?

If the charge, parity, and temporal indicator of the object are reversed, symmetry is preserved and anti-matter is created (*The Arrow of Time*, 1991, p. 139). When anti-matter and matter are brought together both are annihilated, and therefore any object whose temporal indicator is reversed must be sealed off in order that no interaction may take place. This might be possible using strong magnetic fields, but does it solve the problem of the example cited above? The answer to this question -- already argued in Chapter 3 -- is 'No' because, as has already been shown, what is required here is not a relative time reversal but an actual one: not the appearance of time running backwards for an object relative to the external time frame, but the rejuvenation of the object itself such that, as it is taken backwards inside the machine, it actually loses causal history. To see the difference it is necessary to recall Weingard's example. His anti-matter time traveller was created with the memories and physical structure appropriate to a time traveller who had come from the future. As time passed he grew younger, until, at the moment of annihilation, he perfectly resembled the would-be time

8. This effect emphasises the importance of preserving the external/personal time frame distinction when the time machine's journey is past-directed with respect to its immediate surroundings.

traveller, Oscar₁. Suppose he were not annihilated, but instead placed inside a genuine time machine which then began to travel backwards relative to the external time frame. If a genuine temporal reversal (normally equivalent to rejuvenation), relative to the time frame with respect to which one is said to be travelling, were taking place, the being in this example would have to grow older as he travelled backwards, in order that at the moment of arrival at the place of his creation he would perfectly resemble the being who emerged from the anti-matter creator and transmitter. However, anti-matter always behaves in a manner that appears locally time reversed, and in this example that means time reversed with respect to the machine itself (or other beings inside the machine), which is ageing as it travels into the past. Consequently, such a traveller would continue to grow younger, and would therefore fail to replicate the conditions of his creation at the time of his arrival at that moment in the past. A genuinely rejuvenated traveller, on the other hand, would lose causal history as he was carried inside the machine, such that at no instant would he exhibit an age or causal history that was inappropriate to the particular point in time, relative to the external time frame, that he had reached. This would mean that he could only travel backwards within his own life-time, but since he would personally carry no information as to his temporal origins this alone does not appear to pose problems of either a logical or practical

nature. However, the absence of information regarding temporal origins does pose a problem for the definition of time travel.

In the Introduction it was specifically stated that the popular concept required information to be carried into the causal past of the object concerned. If the object loses causal history according to its temporal position relative to the external time frame, that requirement appears to be ignored. In fact this is not the case, because in order to fulfil the definition either the time traveller himself or his machine must reveal their temporal origins, and in this example both do.

The time machine is accumulating causal history as it travels backwards through time, and this effectively obviates the advantages gained by imagining the rejuvenation of the traveller according to his external temporal position⁹. Yet even if this fact were ignored, the physical position of the traveller would be sufficient to provide the information demanded by the definition. This is because throughout the journey, as well as at the moment of arrival, there would be two persons occupying two different positions

9. This scenario can be best understood if the reader imagines a machine at least generally similar to Dr Who's Tardis, where there is a sense of time passing in the reversed direction immediately outside the machine. If, for reasons already stated, such a machine is abandoned as unfeasible, the traveller would either have to rejuvenate instantly at the moment of arrival, or, through some form of action-at-a-distance, lose his causal history according to his position relative to the time frame with respect to which he was travelling into the past -- even if that is on the other side of the universe. Both these suggestions appear, at best, dubious, but if this study is to be thorough, all possible physical combinations that are not inherently contradictory must be taken into consideration.

-- not just at the same moment relative to the external time frame, but also at the same moment relative to the personal time frame -- and this would be achieved without the aid of fission. For example, at the age of 21 the traveller is at university studying philosophy, and at the same age he is also inside a time machine that is travelling into the past and may be thousands of miles from that university. The differing physical positions provide a qualitative difference that ensures that Leibniz's law is not violated, but it also provides information as to the temporal origins of the being not at university, and this raises further issues that must be examined.

Section 4

Annabel and Arthur

When considering the problems posed by Nerlich's stick in the previous section, the difficulty appeared to lie in the fact that one object, at the same place and time (relative to the external time frame), would have to exhibit mutually contradictory states. The stick would have to be both notched and unnotched; the time machine both scratched and unscratched. Since it is apparent that the problem stems from the fact that the objects concerned are attempting to occupy identical spatio-temporal locations relative to external time, while at different temporal stages relative to the personal time frame, might all these problems be overcome by the simple physical movement of the objects

concerned such that these contradictions do not occur? Nerlich is right in stating that a contradiction is generated by his example, and we may therefore assume that if time travel into the past is to be possible these conditions must never obtain; but the question is, can they be avoided? To answer this, another thought experiment must be considered. I have chosen Murray MacBeath's 'Who Was Dr Who's Father?' as an example of the appropriate group, although there are others (Jonathan Harrison provides one in *Analysis* Problem 18). The story-line, paraphrased from MacBeath, is as follows.

Annabel is walking through the forest when she comes across a cabinet resembling a freezer. Inside it is a man who proves to have lost his memory. Annabel names him Arthur and, being of a whimsical frame of mind, makes his last name Who (because nobody knows). In time they fall in love, get married, and produce a baby boy. He so resembles his father that he too is named Arthur. Young Arthur proves exceptionally intelligent, gaining a Ph.D. by building a prototype time machine. Naturally eager to try his machine, young Dr Who is halted by his parents who demand that if he wants to travel in time, he must take someone with him. Arthur senior volunteers and the two set out. Unfortunately, the machine proves to be faulty and the trip far longer than that for which provision had been made. As a result, young Dr Who is forced to murder and eat his father in order to

survive. Eventually Arthur's machine stops and he emerges in a potentially hostile world. He has travelled backwards much further than he had intended, and he is additionally worried that his crime might be discovered. His machine being completely useless, he destroys it and builds instead a freezer into which he climbs. Some years later, Annabel is walking in the forest...

Here is a closed causal chain that does not, at first glance, seem to pose the same problems as Nerlich's closed world line. At no point is the same object asked to occupy the same point in space and external time whilst being physically older. The difference between the two stories becomes apparent if graphs are used to illustrate them (see Fig. 5.4). Whereas the first results in a closed polygon, the second resembles a spiral. Arthur has a beginning and an end, the stick and the time machine do not. Consequently, while young Arthur and old Arthur do not attempt to occupy exactly the same physical space at the same external time, this is not true of the notched and unnotched sticks. Yet despite all this we feel a certain apprehension when asked to believe the logical possibility of Macbeath's story. Annabel and Arthur are easy to imagine (a film could be made of their story), but the actual passage of events that they represent is not, which is why the story generates a feeling of discomfort that is hard to explain. The cause of this discomfort may now be highlighted by a similar, but simpler,

thought experiment.

Young Chronos is handed a file, by his future self, containing instructions on how to build a time machine. In due course he completes the machine and prepares to hand the file back to his younger self -- thereby completing the chain -- but the physical state of the file reveals a causal history that is greater than that which it had upon his receiving it as a young man. In order to circumnavigate the problems already mentioned, Chronos copies the file and consequently -- since he cannot change the past without generating a contradiction -- it is the so-called 'copy' that proves to be the earlier causal stage of the tattered file he now holds. This description -- that duplicates in spiral structure MacBeath's story-line above -- is equally unenlightening until a small emendation is added.

When making his copy, Chronos adds a note to the effect that this is the first copy made from the original that he was handed. When handing the file to his younger self, he asks him to remember to add this index number. However, the copy handed to the younger traveller is labelled (1), therefore the copy made by that young man, when he grows older, must now be labelled (2), it being a copy of a copy -- the status of the original having been indicated by the statement followed by the number (1). Yet the events only occur once in the external time frame, and so the traveller cannot label his copy (2) since on the one occasion he labels it, it is labelled (1), as indicated by the index

number on the file he has just copied. To label it (2) is to create a logical contradiction, in that the file has now been labelled both (1) and (2) at one and the same external time and place, whilst at different points relative to something else (see Fig. 5.5). This 'something else' would appear to be the personal time frame, but what precisely is this 'thing' that plays the part of time in the traveller's life actually enabling?

The contradictory change to the label does not represent the ageing of the piece of paper -- a simple physical phenomenon that is well understood -- nor travel through a third temporal reference such as the previously considered 'super-time' -- the existence of the personal time frame is sufficient to ensure the generation of this paradox. The aforementioned examples both represent the combination of the open world line with the closed causal chain. The attempted re-numbering indicates the greater causal history and consequent growth of information around the closed causal chain that exists through personal time, and it is this growth of information, even if it were not indicated by the changing index number, that generates a contradiction.

The data transmitted have a causal history at the same external space-time of both n and $n+$, and this is a contradiction. If such an event did occur, the growth in subsequent causal history would have to be negated as time

travel into the past occurred¹⁰ in order that contradictions did not arise. Furthermore, when the story was told I chose an arbitrary point at which Chronos began labelling the file copies, but as no part of the chain has causal priority, no point can be chosen, therefore the numbering either cannot start or would be infinite in both directions, containing no first or last number. The non-existence of a first number is unacceptable if it is agreed that the time traveller would not use negative numbers as labels, and the non-existence of a last is contradictory since it would require that the label constantly change. Therefore, if Chronos begins to label his copies, the information generated around the chain must be negated as travel backwards through time occurs, otherwise, regardless of whether the traveller attempts to label his copies from (1) or (∞), contradictions must arise as he reaches (2), (3), or ($\infty+n$). Consequently time travel, where closed causal chains are engendered, can never begin. The physical complications of their generation that were mentioned earlier have now been superseded by the logical problems they engender by their very nature.

The solution to this problem would seem to lie in the negation of all the accumulated causal history as the traveller moves into the past, and this, in turn, brings the discussion back to the point raised in the introduction to this section, regarding the physical location of the time

10. If the information were negated when Chronos or the machine were not time travelling, neither would be able to interact in the world around them.

traveller. The complete negation of causal history required in order that a closed causal chain may exist without engendering contradiction would necessarily include the negation of those events that led to his spatial location at the beginning of his journey into the past. If he was not sitting in his machine at the time period he wishes to visit, he cannot be in it when he arrives; and if he was in New York in 1980, he cannot travel from 2000 to arrive in London in 1980, or even to arrive one foot to the left or right of his position in New York in that year. In each of these examples information regarding the traveller's temporal origins in the future (relative to the moment of his arrival) is provided, and in this way is generated the potential for logical contradiction revealed above. Any causal history that is accumulated as the traveller moves from the present into the past in a closed causal chain must be negated, or the chain cannot exist. Consequently, throughout his journey into the past, the successful time traveller can only occupy those spatio-temporal locations that he occupied as he grew older in the usual manner, i.e. when he was growing up without the time machine.

Should a local and global temporal reversal be achieved within the aforementioned parameters, there will be no means of proving time travel either from past evidence or from future knowledge. There will be no evidence in the past of the incursion of a time traveller, because he will not be physically or mentally distinguishable from his earlier

self; there will be no means of deriving information at the moment of the traveller's return, because even assuming directives to recall or record past events were not erased as the traveller moved into the past, there will be no one in existence in the present after the traveller's journey begins to provide the answers. There would be no difference -- mental, physical, or spatial -- between the traveller and his earlier self. Time travel under this description would be indistinguishable from merely vaporising the would-be traveller: he would effectively be turned back on himself, and there would be no means of determining whether or not he had time travelled into the past or merely ceased to be in the present. Consequently, this description does not fulfil the requirements of the popular system, and must therefore be abandoned.

Closed causal chains can be spread over immense intervals, and while the contradictions generated under the limited and specific conditions chosen for the aforementioned example are, I believe, defensible, some will undoubtedly point out that this argument does not prove time travel impossible. The total negation of all causal history required by such a chain proves that it is not an example of the popular system, because that requires that some information be transmitted into the past. Consequently, since small (i.e. of brief duration) and intimately interrelated (i.e. each stage is a sufficient and necessary cause of the next stage and itself) closed causal chains are

not logically possible, Gödel's claim that they would not, in fact, be physically feasible can be resurrected. For physical reasons, therefore, the traveller will not be able to visit his own immediate past -- i.e. he cannot visit himself as a younger man or (as in Heinlein's *All You Zombies* or *By His Bootstraps*) interfere with those directly responsible for his present status. This argument makes the physical limitation either a consequence of logical impossibility, or a lucky coincidence whose results are convenient to the popular concept of time travel. Whatever the explanation, the traveller cannot enter the local past. However, by using a combination of the defined system of time travel and Gödel's limitation, it is possible to conceive of the traveller visiting the more distant past, and here the causal consequence of events that lie in the past, regardless of whether or not they are known to the traveller, become an important factor. D.H. Mellor refers to these effects when he writes

[o]ne could I suppose object that the 1884 arrival [of Dr Who], if sufficiently unobtrusive, might not have affected twentieth-century events, and a fortiori not Dr Who's departure, so that the two events need not be causally related both ways round. But being unobtrusive does not mean lacking effects, it only means not being perceived. And while Tardis's arrival might well not be seen, it can hardly be invisible. It

must have produced the effects of an incursion of an old police box...with a man emerging from it -- displacement of air, reflection of light, etc. If 1884 saw no such effects, it saw no such incursion.

Mellor, 1987, p. 175.

Thus the question arises whether the consequences of the time traveller's actions might be absorbed by the passage of years, preventing the generation of closed causal chains. If this were possible, the one spontaneous link in the apparent causal chain that was mentioned earlier -- the link whose existence is independent of those that constitute the rest of the chain -- might be inserted, and Chronos might be capable of taking information into the past without logical contradiction (although with the aforementioned physical and conceptual difficulties).

A defence of this position requires either partial or total denial of two assumptions: one is causal transitivity; the other is technically termed a 'sensitive dependence on initial conditions'. The repercussions of these denials for time travel as presently defined will be examined in the following section.

Section 5

Small Details and Causal Relations

The following quote from the doctoral thesis of M.F. Cleugh elegantly summarises the position of those who would

interfere in the past.

Common sense affirms, unhesitatingly, that the effects of a spider's crawl over a room in the Tower on January 1st, 1600, have long since ceased to be felt, and that nothing in the world now would be different if the spider had never crawled at all that day. On the other hand, it also holds that certain events, small in themselves, like Caesar's crossing the Rubicon, have a profound effect on the course of history, and that even today our lives would have been different had they not occurred. Once the two different views have been taken, the way is easy to showing that both examples are in much the same position. After all, a spider's crawl -- though at a different time and place -- was once responsible for important historical events; and in the heat death of the universe, Caesar's conquests will no longer matter. Once we admit that, we are bound to agree that there is no logical halting place between two extreme conceptions. One is, that whatever we do -- our most important decisions equally with the mechanical avoidance of an obstacle -- makes no real difference: it will all be the same a hundred thousand years hence. The other says that everything matters, and that, however trifling the occurrence the world never is as if it had not been.

Cleugh, 1937, p. 214.

The assumption can be made that the mental, physical, and social make-up of the traveller from the future is a consequence of events that occurred both during his lifetime (perhaps specifically to him) and long before he was born. His birth and development will have taken place in a complex interactive environment whose level of social and scientific advancement would be a factor of many years' growth. Had that environment come into being spontaneously, not only would this be a spectacular violation of probabilistic laws as we presently understand them, but it would also deny the possibility of time travel into the past because there would be no past to travel to -- either because it is/was merely an illusion generated by ideas implanted in our memories, or because there would be no causal relation or direct awareness of any stage previous to that in which the would-be time traveller presently existed. In this study it is the concept of time travel into the external causal past of the person or object being temporally relocated that is of primary concern, for only under such circumstances can the problems envisaged in both works of fiction and works of science or philosophy have any bearing. Consequently, further reflections on the possibly illusory nature of our past experience can be disregarded.

Every detail of Chronos' existence -- from his political and social outlook to the colour of his hair; from his memories of past events both distant and more recent, to his hopes for the future -- is a consequence of events that

happened both before he made his trip backwards in time and long before he was born. By visiting his own causal past, therefore, the traveller will be in a position to determine his own being. How can Chronos avoid becoming a part of the intricate web of causal interaction in the past that helped to shape him? Merely being seen may be sufficient, and the accidental destruction of something as seemingly inconsequential as an insect could prove to be a vital incident in the sum total of events that go to make up the present from which he travelled. Ray Bradbury's science fiction tale *A Sound Of Thunder*, *Time and Again* by Jack Finney, Mellor's comment in *Real Time* (quoted above, Section 1, pp. 237-238), and the aforementioned quotation from Cleugh all consider this possibility. Each gives an example of the potentially monumental consequences of apparently insignificant events, and thereby displays evidence of the feature termed a 'sensitive dependence on initial conditions'. It may be that Chronos' historical activities with the time machine will only affect one molecule in his body, or they may affect his entire life, but any effect, from the largest to the smallest, would nevertheless be a result of his own activities. The nature of his existence, in every detail, could be the transitive (or direct) result of an act performed by him in the past, and the performance of that act would be shaped by his physical and mental structure. This engenders a closed causal chain, with all the logical ramifications cited above. It has already been

argued that this problem can be resolved at the cost of the definition of time travel, but that should be considered as the last option. Is there any other means by which Chronos could enter his own causal past without generating a logically contradictory chain of events? Some potential solutions will now be examined.

The first solution denies that the actions of the traveller at moments in his causal history will necessarily propagate a closed causal chain. It is not necessary to introduce spontaneous independent creations in order to achieve this end. Instead, either the causal repercussions of any given act performed by Chronos in the past must die out before they reach the time of his departure in the future, or they must not make contact with him. This argument would seem to imply the existence of an intelligence that can prevent or halt the causal consequences of the traveller's actions, but this is not so. It has already been shown that closed chains lead to logical contradiction; therefore, if Chronos should succeed in his attempt to journey into the past, it is a fact that he will not perform any act that will generate such contradictions¹¹. Under these circumstances Chronos can have no knowledge of the events that transpired on his journey,

11. It is interesting to note that from this premiss it can be argued that the very absence of past reports of time travelling activities is a better proof of their actual existence than if history reported regular incursions by persons claiming to be time travellers. The existence of the latter would indicate either a need to reconsider the nature of causal relations in general, or a need to re-examine the credentials of such claimants.

and this obviates the intuitive response to the problem of freewill (see Chapter 4). In Fig. 5.6, graph A, the causal consequences of the accidental movement of a clod of earth by Chronos at time t_4 die out by time t_2 . Consequently they do not affect him, and no closed causal chain is generated. In graph B, while the causal consequences do propagate to the future, they do not affect the time traveller before the moment of his departure. No one and nothing that has contact with him has been affected and so, while the effect exists, it does not generate a closed causal chain. To what extent are these descriptions tenable?

It is possible that the mere movement of a clod of earth is not of sufficient causal importance as to have its consequences perpetuated through hundreds of years. However, it is equally possible that it could, in which case there remains the chance that the traveller is not affected by it. This latter would seem a realistic possibility in a medieval world where communications are poor, but very remote in the modern world where it is possible for large numbers of people to travel or communicate over great distances every day. This lends support to the point raised earlier, that a journey into the distant past would be more likely to succeed than one into the immediate past of the traveller himself. Difficulties arise because the success or otherwise of the journey is not dependent on the time traveller's cooperation.

Chronos is aware that he can only successfully enter

the past if, as a matter of fact, he will not perform (personal time frame) and has not performed (external time frame) any contradictory act (as defined above). What, then, would go through his mind at the moment he realises that he has succeeded in his attempt to visit the past? To suggest that he would try to fulfil those requirements once he has arrived is to ignore human nature, yet his very success is sufficient proof if not of his acquiescence, then of the causal impotence of all his attempts to the contrary. The very ease with which the traveller could generate such contradictions appears to belie the chances of his success. The displacement of air and the absorption of photons that would be a necessary feature of his existence in the past could be sufficient, and since no proof of his success could ever be traced (regardless of his attempts to the contrary) the whole exercise appears to be of limited value -- except inasmuch as accurate information regarding that time and place could be gathered: reason enough to make the attempt.

A potential problem remains, however, in that the success of his venture into the past depends on whether or not he leaves any traces of his existence, and this might be reinterpreted as implying that the cause of his success is the very absence of any causal resonance generated by his activities, thereby making the absence of a cause appear to be a cause in itself. This issue requires further analysis that will begin with the asking of two questions: is the absence of a time traveller's residual trace a cause of his

trying to enter the past; is the presence or absence of residual traces a cause of his *failure* or *success* in entering the past?. If the apparent non-existence of a traveller at any given moment in the past is a cause of his trying to enter that past, a closed causal chain does not exist. This is because to try is a necessary but not a sufficient condition of a success or failure. Trying does not cause success, and therefore the chain may be interrupted. Furthermore, an awareness of previous events need not even be a cause of Chronos making the attempt, and so once again the chain is severed. What of the second, two-part, question? Can the presence of residual traces cause the failure of a time travel experiment? The answer to this part is clearly 'No', because it engenders a bilking experiment: that he has interfered with the past sufficiently to leave a trace cannot be the cause of his inability to enter that past, because his absence would ensure the absence of those features that would prevent his journey. Can the absence of causal traces directly or transitively cause his success? In order that a successful time traveller leave no trace of his presence in the past, he must first exist in that past, otherwise he is not a time traveller. Consequently the question becomes: does the traveller's presence in the past cause his successful future journey to that past?

A time traveller cannot visit a time in which he never existed, for that would generate a contradiction. To examine

the problem from a different angle, if he did exist in the past he cannot fail to make the journey at some point in the future, for the consequences of that act -- that he walked and breathed in, for example, 11th Century England -- have already been realised, even if they have not directly affected his existence. It is therefore necessary that at a suitable moment in his lifetime he travel to the appropriate moment in the past, and because his failure to do so would also generate a contradiction it appears that a relation does exist, but it is not necessary for that relation to be a causal one. The fact of his existence -- if it was Chronos -- means that he will travel to the appropriate moment, but it is not a cause of the journey, only a necessary condition. Consequently the answer to the question, 'Can the absence of a causal relation be a cause in itself?' is 'No'.

The physical problems of time travel, such as the difficulties in conceptualising a successful journey into the past that were raised in Section 2, yet remain. The physical structure of space-time may be such as to resolve these problems, but that study is beyond the parameters of this thesis. Human psychology and the 'sensitive dependence on initial conditions' mentioned in the introduction to this section also raise immense probabilistic issues. This last (a feature of Chaos Theory) is the key to the problem of time travel within one possible world. It is the (possibly minute) physical consequences of Chronos' behaviour that determine whether or not time travel is possible, and

therefore, while it might be possible for a time traveller to enter the past, the logical support for that claim lies in a physical (and still hotly debated) question: can any act, however small and insignificant, avoid the propagation of causal consequences on an ever-increasing scale? If not, time travel is logically impossible; otherwise, while the necessary combination of factors listed below makes organised time travel into the causal past of the traveller highly improbable, there is no reason why it should not occur. Strong causal relations and the transitivity of those relations are features required not only of the identity criteria of the time traveller himself, but also of the machine he uses and the world in which he exists, and they cannot be selective of their boundaries. Yet what is required is not the absence of causal relations, merely the possibility that a potential cause, itself a consequence of previous events, has no effect, and this is a question not so much for philosophers as for physicists.

Just as in the previous chapter, the problems raised here do not imply logical impossibilities. They do, however, result in a compounded improbability. To succeed in a journey into the past, the traveller must fulfil all the following criteria:

- 1) Restricted Access. He must not enter his own immediate past to communicate with himself or those in a position to communicate with him before the moment of his departure.
- 2) Freedom of Will. Upon successfully arriving in the

distant past, the traveller's awareness of his success cannot and will not shape his behaviour in such a manner that his subsequent activities cannot fail to have causal consequences that will affect him before his departure -- e.g. he cannot affect the outcome of the Battle of Hastings such that Harold wins.

3) Co-temporal Events in External Time. The existence of the personal and external time frames -- necessary to resolve other contradictions in time travel -- negate the need for backward causation, but in their place the successful time traveller will demonstrate the need for a radical reconsideration of our understanding of time or dimensions. For in order that an effect can occur, the cause must exist, and since, in the case of time travel, the cause lies in the future relative to its consequence, the previous or co-temporaneous existence of the cause must lie relative to a time frame other than the external (due to its definition) or the personal (due to problems with explaining the duration of the journey) time frames so far defined.

4) Consistent Success. In order that the time machine may be a practical invention it must work on the majority of those occasions on which it is employed. This further compounds the problems cited in (1) and (2).

The high improbability of time travel under these circumstances would appear to be sufficient to warrant the exploration of alternative avenues that are beyond the confines of the definition of time travel adhered to so far.

There are two alternatives. The first I will examine necessitates an appeal to possible worlds. In the last chapter, I considered a branching system as a solution to the problems posed for freewill when considering the time traveller from the future. The conceptual problems that were found made their use extravagant under the circumstances. However, in the light of the above discussions it now seems appropriate to re-examine the possible worlds thesis.

Section 6

Causal Relations and Possible Worlds

The most minimal examination is all that is required to show that the branching system of possible worlds suggested in the last chapter needs revision before it can be considered of any use to the present discussion. This is because, as it is presently described, such a system would entail the traveller's entering his own past for (at the very least) a split second, and it has been argued that this is sufficient time for him to generate a closed causal chain with the logical contradiction that that entails. The high improbability of backward time travel under these circumstances makes the avoidance of such structures an important factor in determining a possible worlds system suitable for Chronos. However, the system chosen must nevertheless preserve some form of causal connection between this world and the one which Chronos enters if it is to be ensured that time travel, and not merely inter-world travel,

has taken place. This requires that a potentially contradictory situation be resolved: namely, that the system exhibit causal connections between worlds frequented by the time traveller, while at the same time preventing the possible generation of closed causal chains that can arise from travel into the past.

One solution might entail Chronos entering an alternative world (W2) immediately he begins to travel backwards through time, as illustrated in Fig. 5.7. This would prevent his entering his own past, and so it would prohibit the possible generation of a closed causal chain in this world, but could Chronos then halt his journey in the past of W2, affect that world, and then remain there until it coalesced with W1?

Chronos left W1 at the instant he began his journey into the past; consequently, he does not exist in W1 in the time after his departure. If he attempted to remain in W2 until it joined W1, he would either generate a contradiction -- by coalescing with an earlier person stage -- or he would have to spontaneously appear (without the aid of his time machine) in W1 immediately after his departure. The contradictions outlined in the former suggestion cannot occur, nevertheless the latter solution seems, at best, highly improbable.

The close proximity of Chronos' departure and arrival would be such that he would not seem to have left, although his physical location and mental condition may differ

considerably, indicating some change in his state. Yet if a person existed in one world who did not exist in another, or occupied a position occupied either by a person who differed either physically or mentally, or by an inanimate object, or by air molecules and photons in the other world, those two worlds would differ and therefore they could not coalesce. Furthermore, using this model the only method by which W2 and W1 could merge after Chronos' initial departure would be if W2 somehow altered its path before a contradiction was generated, and there seems no simple explanation of such a convenient fission. In Chapter 1 it was argued that a galaxy or object would be invisible to people who were time reversed with respect to it. Martin Gardner (1967, p. 102) adds that there are some (he cites F. Russell Stannard's article, 'Symmetry of the Time Axis', in *Nature*, August 13, 1966) who would argue that two galaxies or objects that were time reversed with respect to one another could not interact in any way. Consequently there might not be any indication (arising from the existence of the backwards moving time traveller) of the contradiction about to be generated at the merging of the two worlds until after (*per impossibile*) the contradiction had occurred; and even if there were, to suggest that a world might alter its course in anticipation of events to come is to imbue possible worlds with sentience. While the traveller can play an active role in altering his path between worlds (although he cannot decide which particular world he will enter as a consequence of his

actions), a possible world cannot determine or alter its path. Nor should it be supposed from this claim that the introduction of a third possible world, into which the traveller moves as soon as he is in danger of generating a contradiction, will resolve the problems of this model.

In order to enter another possible world from W2, Chronos would have to attempt an act with the potential to generate a contradiction, as was the case when he departed W1. But whereas in the latter instance Chronos' entry into W2 ensured the potential for contradiction was not fulfilled, in this model his mere existence (however brief) in the past of W2, which would be necessary to create the potential for contradiction necessary to ensure his relocation, could be sufficient to actually generate that contradiction, because there exists an earlier person-stage in the future of W2. This is due to the fact that if one assumes fission will not take place, it follows that W2 will only connect with W1 at the point of Chronos' initial departure. Under such circumstances an earlier person-stage would exist in the future of a world that contained an older person-stage in its past -- the same difficulty that makes time travel within one possible world highly improbable, if not impossible. Failure to recognise this potential arises from a tendency to imagine each world to be independent, forgetting that the intersection of worlds 3, 2 and 1 is a world in itself (see Fig. 5.8). Thus this model is shown to be unsuitable to the needs of the time traveller.

To resolve the above difficulties, imagine that the traveller follows a curved path into an alternative past (see Fig. 5.9). Chronos moves into the alternative world as soon as he begins to travel by means of the time machine, branching off into a loop that takes him into the past, where he resumes normal temporal movement. At no point does Chronos exist in both the future and the past of one world at inappropriate person-stages (i.e. the older stage existing at the earlier moment relative to the external time frame), because his route is always future-directed from the local perspective -- despite its eventual success in re-locating him in the global past -- therefore there is no potential for the generation of closed causal chains. Nor does Chronos attempt to re-enter or merge with the world from which he initially departed, but problems do remain.

The point labelled A in the diagram is the moment of his departure in, for example, 2000 AD. Point C is the moment at which he resumes normal temporal movement in W2 (i.e. leaves his time machine). Point B is the date 1066 AD in W1. From this, two questions arise. The first concerns the ontological status of W2: is it a world at all? The second concerns the temporal agreement between W1 and W2: why should the time at which Chronos resumes normal temporal movement in W2 be equivalent to the date 1066 AD in W1?

The nature of W2 is, at best, ambiguous. If its temporal indicator agrees with that of the external time frame (labelled Y), as illustrated in Fig 5.10, there will

come a point where it must be reversed, due to the looped construction of W2. Therefore a point must exist where the change-over between one temporal direction and the other takes place. The change-over point exists somewhere between 1 and 2, and must be negotiated by the traveller. The concept expressed in this diagram provides a clue as to the real nature of W2, but before it is examined consideration must be given to the alternative. Suppose the temporal indicator did not agree with the Y axis, but instead flowed from point A in a positive progression such that his departure from W1 in 2000 AD is followed in due course by his passing through 2001 AD in W2 (see Fig. 5.11). This echoes the original description of the Gödelian space-time model in that Chronos himself would always move into the local future, but if the world in which Chronos exists is also moving into the future, at what point will it suddenly become the global past? Under this description, W2 becomes not the world closest to W1 at point B, but a world closer to W1 at point A. Since the temporal indicator of the world itself -- and not just the temporal indicator of Chronos when travelling through it -- is always future-directed, all that Chronos will achieve by means of a journey through W2 would be entry into the future of an alternative to W1 -- a world that appears to lie in the past relative to the moment of his departure, according to an external time axis that is otherwise impotent. This is clearly contradictory, since it implies that at the external date 1066 AD (indicated by its

position relative to the Y axis), W2 is at time $2000+n$ AD, the sum of n depending on the time covered by the loop of W2. Once again, there is an analogy here that reveals the status of W2 as something other than a possible world. It is Chronos who is travelling backwards and then forwards through time in Fig. 5.10. It is with respect to Chronos alone that time continues to move in the positive direction while he travels backwards in time (relative to the Y axis) as in Fig. 5.11. Therefore W2 is not a world at all between points A and C, but the route taken by Chronos into the past.

If these arguments show that Chronos cannot exist in an alternative possible world as he travels through time, where does Chronos exist during his backward movement? A yet higher dimension; a form of 'super-' or 'hyper-space' that is as yet undiscovered? While this solution may be applauded by science-fiction writers, who have for many years appealed to the use of higher dimensions by space-ships travelling at super-luminal velocities, it is not one that can be carefully analysed, and so leaves many questions unanswered.

An attempt at answering the second problem raised above was provided when the nature of possible worlds accessible to the time traveller was examined in Chapter 4. There, I wrote that all such worlds must have an agreed temporal reference. In this way, the boundaries of the external time frame were extended such that it ceased to be 'time at rest with respect to the history of the planet', and instead

became 'time at rest with respect to the history of the planet and every possible world accessible therefrom'. This common temporal reference implied the existence of an absolute time frame relative to every possible world, and this in turn had repercussions for another claim of Chapter 4, where I argued that the traveller must first travel in time and then move to another world, and not merely jump from world to world and claim that such activity is time travel. A journey into the past within one possible world, to be followed by movement into another possible world has been shown to be either improbable or impossible, depending on the nature of causal relations. It is all the more important, therefore, that some agreed absolute time frame be determined according to which Chronos can claim to have moved into the past. However, as with so many of the arguments appealed to throughout this thesis in an effort to preserve logical sense in descriptions of backward temporal movement, the concept of an absolute external time frame existing outside all possible worlds is acceptable only so long as it is not subjected to close scrutiny, for at that point it becomes meaningless. It is a time frame existing outside all worlds of time and space, and because the time machine and its occupant also have spatial dimension, and consequently must exist in space as well as time when journeying into the past, this 'higher' time dimension must also contain a spatial dimension. From this it may be concluded that all possible worlds exist inside some larger

possible world; and if that is so, then why not still larger, all-encompassing possible worlds, and so on? It might be argued that the existence of time in our world is dependent on the existence of this higher dimension, and consequently an infinite regress need not be generated, but this claim is highly suspect and unsupportable. Thus, not only are there an infinite number of possible worlds that branch from each alternative provided in this world, but all these worlds are contained within another world that may (there is no reason to think otherwise) be a part of yet another intricate branching, and so on. The theoretical advantages of this system of possible worlds for the time traveller do not seem to be sufficient to overcome their fantastic ontological requirements.

Further problems remain. If the world existent at point C (Fig. 5.11) is to be considered the closest possible world to ours in 1066, this would seem to necessitate some form of connection between points B and C at that time. Without this link, since Chronos' route is indirect, the world he witnesses at 1066 AD may bear little or no relation to the world at that time as we know it. Merely by travelling backwards in time, Chronos cannot guarantee that a world causally unconnected with W1 until 2000 AD will resemble W1 in 1066 AD. While it is possible to predict with varying degrees of accuracy the effects of a given action on future events, it is impossible to work the other way and, by examining present conditions, correctly identify the causes.

This is because the same result may be achieved in a number of different ways.

In this model there does exist a relation between W1 and W2, as expressed by the existence of Chronos in both. The relation is not of logical concern, though, because Chronos does not come from the future of W2 and so would be equivalent to a person from another, far more advanced, planet interfering in the affairs of 11th-century mankind. However, the lack of causal connection at point C is a matter that requires resolution, for the reasons mentioned above. In order that W2 may be the closest possible world to W1 at point B, there must be some causal connection between the two. This can be effected by the provision of a connecting line, as illustrated in Fig. 5.12. There are now two methods by which entry may be gained to W2: the first is the route created by the time traveller, beginning at A and ending at C; the second is achieved by means of an alternative possible outcome arising at point B, which marks the initial creation of W2 itself.

Once Chronos has entered W2 at point C, he cannot re-enter W1 by means of the section of W2 existent between points C and B, and neither can he enter W1 at any point in the future relative to point B that is antecedent to the moment of his departure at A. In each case, the reason lies in the causal chains that would subsequently be generated. He would also be prevented, more by probability than by logic -- as previously mentioned in this section and in the

last chapter -- from re-entering the future of W1 after point A. Thus he may become lost in the infinity of possible worlds that he must use, and so even if a way was found by which the aforementioned conceptual and causal problems might be resolved, it appears highly improbable that there will ever appear any incontrovertible evidence that inter-world time travel has occurred.

I have suggested a system of possible worlds to be used by a time traveller into the past who wishes to ensure the closest possible approximation to backward time travel into his own causal history, but the system is not satisfactory. In order that coherence may be preserved it has proved necessary to appeal to an accessible space between worlds, an absolute temporal reference for all possible worlds accessible from W1, and (although it has not been specifically stated) in order to preserve the energy conservation principle the total energy in the system must be the sum of that contained in every possible world, not merely that contained in any given one. If this were not the case, the sudden appearance of Chronos at C would be a violation of that principle which, while being a physical rather than a logical limitation, should be taken into consideration¹². There also remain questions regarding the

12. It should be explained that there is a difference between the traveller's sudden appearance in another possible world as a result of his time travelling activities, and the coalescence of two possible worlds of differing content that I rejected earlier. The traveller is active in determining his movements, and his sudden appearance can be explained by his time machine's properties. There is no reason to suppose that the departure of Chronos from a world will result in anything more than his subtraction from the sum total of that world, and his addition to the sum total of the other. A sudden

ontological status of such a system of possible worlds, their accessibility, and their structure. Satisfactory solutions to all these problems must be found before possible worlds can be presented as a viable alternative to the highly improbable popular system of time travel.

With so much left unresolved, the proposed examination of the nature of change across possible worlds that was mentioned in the previous chapter cannot be fully realised. Even though there may be evidence for the necessary existence of direct causal relations between any given moment in W1 and the moment in W2 visited by the traveller in an attempt to experience and 'change' the past, the necessarily independent nature of the two moments to be compared, as well as difficulties with defining or explaining the existence of time frames relative to which inter-world time travel could take place, effectively prevent further analysis.

From the above it is clear that any temporal movement that attempts even an approximation to travel into the causal past of the traveller demands either a highly improbable combination of factors together with an incomprehensible system that allows the mutual co-existence of past, present, and future, or the existence of a complex and ultimately unsatisfactory system of modal realism that

influx of creatures from the world into which he has moved would be both unnecessary and absurd (another reason for questioning the possibility of time travel under these conditions). It is incompatible with the final model of inter-world time travel outlined above.

also depends on some extra-world time frame. Yet I have not ruled out backward time travel altogether, as there remains one alternative yet to be examined.

Section 7

Relative Time Travel

Time travel into the relative present is, at first glance, an acceptable consequence of high-velocity spatial movement. The traveller enters a space-ship and then moves off at high speed to a neighbouring star system. From there he sends a message back to Earth at near light speed as proof of his achievement. By comparing the distance the message has travelled with the time taken to complete the journey, it would be possible to determine how far into the past the traveller had journeyed. If the traveller were to send a message from the star system of Alpha Centauri -- which is approximately 4.3 light years from Earth -- the message might arrive only five years after the departure of the astronaut/time traveller, indicating his existence in that star system at a time more than three years before his message reaches Earth. Provided that the message cannot be sent on to reach Alpha Centauri before the traveller sends it, no logical contradiction would be generated¹³. However, even with this system problems may arise.

13. Were the traveller's machine and the message both to move at light speed (per impossible) the message would arrive, at the earliest, 8.6 years after the traveller's initial departure. This is not satisfactory. Consequently, the traveller must use a short-cut, e.g. a worm-hole, to shorten his journey time in order that the message may arrive after the interval suggested.

As the astronaut travels through space and time he must ensure that he never enters the backward light cone of one of his own past or present endeavours, because this would generate the same potential for logical contradiction arising from closed causal chains as a journey into his own past light cone here on Earth. The potential for such violations will depend on the velocities achieved and the area covered by such an astronaut. Yet because what is logically impossible cannot occur, there remains the argument that, as a matter of fact, the traveller simply does not place himself in a position where logical contradictions must arise. Thus, even were the physical potential realised, it would remain a matter of fact that he would never enter the backward light cone of his own past actions, or he would simply refrain from any action that might generate a contradiction. While it is necessary that one or other of these conditions be satisfied if the traveller is to continue with his activities, as with the conditions for time travel into the causal past of the traveller on his own planet, their fulfilment in this example seems either miraculous or highly suspect. The full impact of the last option is succinctly summarised by William Lane Craig, in his article *Tachyons, Time Travel and Divine Omniscience* where he considers a situation where it is possible to generate logical contradictions (in his case he appeals to the Tolman Paradox¹⁴, but the effect is the

14. First suggested as early as 1917, the paradox envisions the following scenario: Person

same), but the young time travellers involved refrain from performing the required acts because they are ordered to do so. Craig writes

*does the very structure of space and time
thus depend on the obedience of callow, young recruits
to their commanding officer?*

Craig, 1988, p. 146.

This might equally apply to Chronos. Is the entire structure of space and time to depend on his conveniently refraining from any act that might generate a logical contradiction? Clearly, the answer is 'No'. If it is a fact that Chronos cannot perform a certain act -- not because he is constrained, but because it is akin to a mathematician attempting to square the circle -- then his travels must necessarily never place him in a position where it would be possible for him to perform that act. The simplest way to achieve this aim is by the denial of any system of backward time travel that might engender such consequences. Hence, not only is backward time travel into the immediate causal past of the time traveller shown to be highly improbable and, depending on the physical nature of causal relations, logically impossible, but so too is any system of backward temporal movement with the potential in due course to create

A sends a message backwards in time to person B if and only if he does not receive a message from person B. Person B sends a message forwards in time to person A if and only if he receives a message from person A. Hence the message is sent if and only if it is not sent.

the same contradictions. Backward temporal movement across immense inter-stellar distances is therefore logically possible, provided that the amount of backward temporal movement is always balanced by the amount of time spent in achieving it. As a matter of logical, rather than physical, fact, no velocity can ever be achieved or short-cut be used that might generate a contradiction along the lines discussed in this thesis.

In these chapters I have analysed every aspect of the time traveller's nature. It is now time to pull together all the strands of the arguments that have arisen from these studies, and consider the conclusions arising from them and the potential for further research that they indicate.

