Concepts of time

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> Time has always been difficult to understand, but in the twentieth century, our ununderstanding has become clearer.
>
> J. R. Lucas (1999: 1)

1. Introduction

The experience of time and the need to adapt our life to it are as old as mankind. The sun rises in the morning and sets in the evening, the moon changes its position at regular intervals, plants and animals and humans come into existence, grow, fade and pass away. We act here and now, but we also remember having acted, and we plam and hope to act in the days ahead of us. Some of these events, such as the coming and going of the seasons, are cyclic, that is, they are repeated at intervals which we consider to be equal. Other events are not assumed to be cyclic, such as our first love, the birth of Jesus, or Grandmother's death. All human cultures and societies of whom we know have reacted in three ways to this temporal nature of experience:

- First, *actions are planned and done* accordingly – there is a time to plant and a time to reap; a time to tear down, and a time to build; a time to mourn, and a time to dance, as the Preacher has it in the Bible.
- Second, methods to *measure time* were invented. This is always done by linking some event – the event whose duration we want to measure – to some other type of events which are supposed to occur at regular intervals, such the sequence of the seasons, the fall and rise of the sun, the swing of a pendulum, the oscillation of a quartz crystal; the result are calendars and clocks (Bruton 1993; Landes 1983; Richards 1998).
- Third, we *speak* about time. All human languages have developed numerous devices to this end, and in some languages, the marking of time is even close to mandatory. In English, as in all Indoeuropean languages, the finite verb regularly expresses "tense" – that is, the sentence not only describes some event, process, or state. It also places this situation into the past, present, or future: we cannot say *John be ill*, thus leaving neutral the time of the state thus described. We must say *John was ill, John*

> *is ill, John will be ill*. Other languages, such as Chinese, have no mandatory marking of time. But this, of course, does not mean that they cannot express time; they just use other means, such as adverbials like *yesterday*, *right now*, or *very soon,* and they give their speakers full freedom to indicate what happened when.

So, we all adapt our life to time; we use devices by which time is counted and measured; and, above all, we speak about time. We know what it means when someone says *He will arrive tomorrow at five.*, *The meeting has now lasted for almost eleven hours*., and *Last february, I intended for the first time to spend more than three hours per week in Pontefract*. So, we do understand what time is. But what is it, then?

At this point it is common to quote St. Augustine, who, in the 11th book of his *Confessions*, says:

> Quid ergo est tempus? Si nemo ex me quaeret, scio. Si quaerenti explicare velim, nescio.
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> [What, then, is time? I nobody asks me, I know. If I should explain it to someone who asks, I don't know].

His own way to overcome this clash between practical and theoretical understanding of time is that time is not in the things themselves but in our soul. God, he says, is beyond time, and we get to know all things created by him because he has endowed our soul with memory, experience, and expectation (see Flasch 2004). In other words, our soul – or our mind, as we would probably say now –, is such that we experience the world as *past, presence,* and *future*.

St. Augustine's theory of time is one of many within a rich stream of thought that began with the first Greek philosophers and has steadily unfolded over the millenia and over many disciplines – philosopy, physics, biology, psychology, anthropology, linguistics, to mention but these. They all deal partly with the same and partly with different aspects of time, the result being a hardly permeable jungle of views, opinions, and theories. In fact, the Augustinean question "Quid ergo est tempus?" has found so many answers that one might as well say that there is no answer at all. Thus, the idea that we could ever grasp "the essence of time" is perhaps futile; is is doubtful that there is much more than a kind of family resemblance between a biologist's, a phycisist's, and a psychologist's concept of time.

The aim of this chapter is not to unveil the "very nature" of time; it is rather to prepare the ground for a basic understanding of how temporality is

expressed in natural languages.[2] To this end, it is necessary to gain some idea (a) of the underlying temporal notions, and thus of what people understand by "time", and (b) of the means by which these notions are encoded in the different languages of the world. The second issue is addressed to the following chapter of this book. The present chapter is devoted to the notional category of time. Section 2 reviews the diversity of meanings with which this category is associated; we will glance at some of the key questions which are dealt with in different fields. Section 3 discusses three perennial issues which come up time and again when people reason about time. In section 4, I will sketch a "basic time structure", which, I believe, can serve as a useful starting point for the study of how time is expressed in language.

The following exposition is strongly biased towards "the Western tradition" of reflection on time. Apart from shere lack of knowlege on my part, this bias has three reasons. First, it is by far the best studied tradition; there is, of course, research on non-European notions of time; but it is comparatively sparse (see, e.g., Needham 1968; Fraser, Haber and Lawrence 1986). Second, only in that tradition do we find this enormous spread of temporal notions across various disciplines, such as physics, biology, or psychology. Third, different as human languages are – our entire way of thinking about their lexical and structural properties is deeply shaped by the Western tradition of linguistics. In Latin, the word *tempus* means both "time" and "tense", and thus, one is easily led to believe that tense is the most immediate reflection of time in language, in fact, that tense is time. This close connection has misled not only linguists but also philosophers who think about time, and so, it is important to understand its roots.

2. The variety of time

This section is a gaze into a jungle – into the rank growth of notions, ideas, problems which have grown from a few germs laid in the Antiquity. At first glance, it would appear to be hopeless to detect any structure in this jungle; but in fact, there are a few recurrent themes which we will address in the following section. It should be clear that this panorama is anything but ex-

[2] The number of books on time is legion. The best general survey is to my mind Whitrow 1980; it is, however, confined to time in philosophy, physics and biology. Fraser 1987 is an easy and broad introduction by one of the best experts on the study of time.

haustive: it is simply meant to give an impression of the abundance of temporal phenomena.

We will begin with philosophy – the mother of any science and the origin of human thought on time. In fact, any such reasoning reflects a particular perspective on reality and the way in which we are able to recognize it – a perspective on us and on the world around us. In this sense, any reflection on time is inevitably "philosphical". But if we speak of "philosophical" theories of time, in contrast to, for example, physical theories, we normally mean the more or less elaborate views of particular philosophers, from Anaximander[3] to Heidegger and Wittgenstein. There are many such theories; here are three characteristic examples from modern times; they stand for very different perspectives on time (Turetzy 1998 is an excellent survey; Le Poidevin and McBeath 1993 is a characteristic collection of articles on 20th century philosophy of time).

A. In Immanuel Kant's *Critique of pure reason* (1781), time and space are properties of human cognition – in fact, the two most fundamental categories of human cognition. They define the way in which our mind experiences, and thinks about, the world. Time, in particular, is "die innere Form der Anschauung", (the inner form of intuition). It defines the way in which we "intuit" external events and facts, such as the running of a horse or the rotation of the earth, but also internal events, such the feeling of hunger or grief. We cannot know whether time is "real", that is, a property of the world itself; our cognitive apparatus is such that the outer as well as the inner world inevitably *appear* to us as structured by time.

B. In his influential article *The unreality of time* (1908), the British philosopher John McTaggart argued that there are two types of event series, each of which represents time: The "A-series" relates to the "earlier-later"-order, to the mere *succession* of events, states, processes. In this sense, Aristotle lived before St. Augustine, and Kant lived after St. Augustine. The "B-series" relates to the difference between "past – present – future". In contrast to the A-series, it requires a particular vantage point, from which the events are seen; this is the present moment – which, in turn, permanently shifts. Under neither understanding is time "real", argues McTaggart (see, e.g., Turetzky 1998).

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[3] In what is probably the oldest fragment of Greek philosophy we have, Anaximander says that the things, as they come into existence and perish, "pay their debts to each other according to the order of time" ("kata tou chronou taxin") – a sentence of which no element is easily understandable (see Turetzky 1998: 6–8).

Kant's and McTaggart's views on time are among the most-discussed in modern philosophical literature; but they are not really new – they elaborate and extend themes that are already found in the antiquity. As we have seen above, St. Augustine also thought that time is a property of our "soul", and that it divides the world, as we can recognise it, into past, present, and future; he also had a clear notion of succession being a crucial feature of time. This is quite different for the third philosophical theory of time which I will mention here.

C. In Martin Heidegger's book *Sein und Zeit* ("Being and Time"), published in 1927, time is not so very much seen as an objective property of the world around us or a subjective property of our way to know the world in or around us. Rather, it is something that shapes human existence. Human time is not an abstract order, real or imaginary, defined by relations such as "earlier" or "simultaneous". It is the slope which separates us from death, a short stretch filled with our sorrows and efforts and griefs. It is the notion of time which surfaces in expression such as "little time is left", "these were hard times", or, in the words of the Preacher quoted above, "there is a time to plant and a time to reap; a time to mourn, and a time to dance". Such a notion of time is not incompatible with the idea of succession and the division into past, present and future; but properties like these are somehow marginal to what time means for humans.

These are three of the very many ways in which philosophers have looked at time. They may not be mutually exclusive; it is not even clear whether they target the same entity or not. And in a way, we do not expect the opinions of philosophers to converge on some phenomenon. But we do expect this in hard science. So, there should be one notion of time in physics. This is not the case. There are at least three approaches towards this chimera.

D. The first of these is the view which underlies the laws of classical mechanics, as first stated by Isaac Newton. In the introductory "definitions" to the *Principia*, Newton distinguishes two notions of time:

> Tempus Absolutum, verum & mathematicum, in se & natura sua absque relatione ad externum quodvis, æquabiliter fluit, alioque nomine dicitur Duratio: Relativum, apparens, & vulgare est sensibilis & externa quævis Durationis per motum mensura (seu accurata seu inæquabilis) qua vulgus vice veri temporis utitur; ut Hora, Dies, Mensis, Annus.
>
> (Newton, Principia, Book I, Scholium to the Definitions)

['Absolute, true, and mathematical time, in itself, by its very nature and unrelated to anything external, flows equably, and is also named Duration: relative, apparent, and everyday time is some sensory and external (accurate

> or unequable) measure of duration by motion, and it is is commonly used instead of true time; such as hour, day, month, year.']

A number of points are remarkable in this short paragraph:

(a) Time is the same as Duration. It is neither an order, defined by "earlier" or similar notions; nor is it in any way related to past, present, future. This does not mean that Newton had no idea of *succession*; in a somewhat mysterious way, it comes in in the term "aequabiliter fluit". But in its absolute as well as in its relative understanding, Newton equates time with *duration*.

(b) We cannot measure "real" time – whatever it is. Instead, we measure the duration of things to which our senses have access. This duration is "relative time"; it is measured by motion, and the result are units such as hour, day, year, etc.

(c) Real time is always the same; still, it "flows", and it flows equably – whatever that means. Newton does not say whether it flows in one direction, although this would seem the most natural assumption. Real time is, so to speak, unaffected and unaffectable by anything. In fact, it is not even related to anything "external"; in particular, it is not related to any *observer*.

Newton's notion of real time is cryptic, perhaps because it has a strong religious background. As he states in the Scholium Generale of the second edition of the Principia (1713) – an addition which particular famous for Newton' statement "Hypotheses non fingo (I don't make up hypotheses)" – he argues that time is an emanation of God, and God is in time (a position which is in sharp contrast to St. Augustine's, according to whom God is out of time). It may well be that the tremendous success of Newtonian mechanics is completely independent of his conception of "real" time. What is crucial for the laws of motion is the possibility of measuring the time of observable events by motion. This is not possible for real time. What really matters in Newtonian physics is thus relative time. Absolute time, dear as it may have seemed to Newton, is something that lurks in the background, and is perhaps completely superfluous to the physicist.[4]

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[4] His great opponent Gottfried Wilhelm Leibniz argued that time and space are purely relational – there is no absolute time and no absolute space. In response to this, Newton's spokesman Samuel Clarke gave an argument as to why we need something like "empty space", independent of the properties of objects that are "in space". But no corresponding argument was ever given for "empty time" (see Westfall 1983).

E. Classical physics, including its notion of time as duration, sometimes leads to undesirable asymmetries. If, for example, a conductor and a magnet move in relation to each other, then there is a electromagnetic effect. This effect should be the same no matter whether the conductor moves, or the magnet moves. But classical physics gives two completely different accounts of the effect for both cases. The problem disappears if we assume that there is no "distinguished frame of reference", in particular no absolute frame of reference, as seems to be implied by absolute time and space. We can choose the position of the conductor as well as the position of the magnet as frame of reference; the laws of physics operate in the same way, no matter what the frame of reference is; the only factor that remains constant is the velocity of the light. This is the basic idea which Albert Einstein worked out in in 1905 in what was later called "special theory of relativity" and which, among others, led to the notion of "relativistic time". This time has peculiar properties, which are often felt to be paradoxical; thus, it may shrink or extend – an idea which seems very different from a notion of time which flows equally and is unaffected by anything external, and no less different from our everyday notion of time.

Usually, a sharp constrast is made between Newton's absolute time and Einstein's relativistic time. This is misleading, because in actual fact, Newtonian physics does not operate with absolute time, either. Absolute duration (scil. absolute time) exists, but it is not accessible to us; all we can measure is relative time. What Newton did not consider was the possibility that the measurable duration of some event could vary with a frame of reference ("Koordinatensystem", as Einstein says in German); exactly this assumption is made in Einstein "relativistic time". But Newton never spelled out how relative duration differs from absolute duration, except that the former is a familiar phenomenon and can be measured by motion, whereas the latter is the "true" duration.

Relativistic time and Newtonian time (in both variants) have three properties in common:

(a) What is crucial, is not so much the "earlier – later" order of observable phenomena – their *succession*; it is their *duration*. The famous and perplexing "time dilation" and "time contraction" effects of the special theory of relativity refer in the first place to changes in the duration of some observable phenomena, when measured from different frames of reference. But indirectly, varying duration also affects observed simultaneity and succession between two events. The reason is that *information* about these events needs some time to reach the observer, and this

time takes longer or shorter, depending on the relative distance between the place where the events occur, and the frame of reference.

(b) The laws of physics operate equally "in both directions". They do not go "from earlier to later" or "from later to earlier". This asymmetry, so fundamental to the daily experience of time, plays no role under these two conceptions of time.

(c) Similarly, the observer – the person who experiences time – plays no role. There is no past, present or future, no shifting Ego, in relation to which these notions are defined. In relativistic time, there is always a "frame of reference"; but all that is relativised is duration. Einstein never denied that past, present and future are important ingredients of everyday notions of time; but not so in the world of physics (cf. section 3.3 below).

Since the laws of physics do not conform to an "arrow of time", which invariably flies from earlier to later, they reveal the kind of symmetry which physicists like; the theory of special relativity started as an attempt to overcome an undesirable asymmetry. But has nature really no earlier-later orientation? Is the real world, whose laws the physicists try to find, like that? Questions of this sort have given rise do a different notion of physical time.[5]

E. We can imagine that an egg, once fried, returns to its initial state; we can even have a film run backwards, thus apparently reversing the order of time. But we never observe such a return in reality. There are many physical processes which, it seems, obey the "arrow of time". A well-known type of such unidirectional processes are the changes of entropy (roughly: the amount of disorder) in a closed system, as studied in thermodynamics. In **Clausius' formulation from 18651, the second Law of Thermodynamics** states that the overall entropy (roughly: the amount of disorder) of a closed physical system can remain constant or it can increase; but it cannot decrease, unless such a change is caused by influences from outside the system: inherent state changes of the entire system are unidirectional. This has given rise to a physical concept of irreversible time, a concept which is neither Newtonian nor Einsteinian (see, for example, Prigogine and Stengers 1993). It should be noted, though, that irrreversibility is not to be equated with the earlier-later asymmetry, as is often done. Even if the fried egg

[5] Reichenbach (1958) is still a very clear treatment of this problem; see also Horwich (1987) and the contributions in Savitt (1993) for a more recent discussion.

could be restored, the time at which at which it has its original shape again is *later* than the time at which it was not yet fried: the egg is as it was *before*. We will come back to this problem in section 3.1.

The time of physics, in whichever of the three variants mentioned here, does not integrate some of the features which we normally associate with time. It deals with the temporal structure of dead matter, not of living organisms. There are at least three notions of *biological time* – the life span of the individual, biological evolution, and biological rhythms in the organism.

F. The life of an indivdual has a beginning: birth (or perhaps conception). It has an end: death. And the processes between birth and death are, as a rule, not reversible: they have a certain duration, and they are fundamentally characterised by the earlier and later of growth and decay. This second fact makes biological time crucially different from physical time in the Newtonian or Einsteinian sense. It makes it also different the time notion of thermodynamics; there is no organic "growth and decay" in the changes of closed systems, except in a very metaphorical sense.

G. Antique and mediaeval thought did not consider the world as entirely static. There are changes, such as the motion of bodies, the changing seasons, or even the notion of subsequent ages – for example, a "Golden Age" followed by a "Silver Age". But it was not until the late 18th century that the idea of *evolution* gained ground – that is, of a temporally directed and rule-governed process which determines directed changes of whole systems, usually towards an increasing complexification. The earliest detailed treatment I am aware of is by Johann Gottfried Herder (1784, vol. I). Such systems might be, for example, *languages*; Hermann Paul, one of the leading linguists of the 19th century, even argued that only historical linguistics deserves the name of a science, because only this way of looking at language reveals the principles that underly it, rather than merely stating facts Paul 1882: 20). They might be *physical systems*, such as the earth, the solar system, or even the entire universe. But by far the most discussed example is the origin and evolution of *life*, which, as is now generally believed in the educated world, is determined by a few principles such as genetic variation, extinction according to fitness, or drift.

H. There is a third way in which we can speak of biological time. Many processes within a living organism follow a "biological rhythm", for example the circadian rhythm which, as a rule, lasts 24 hours in human beings,

though with considerable variation. These rhythms are essentially determined by a "timer" – maybe several timers – inherent to the organism, but this internal timing interacts with influences from outside the organisms, for example the amount of light or heat. This highly complex and only partly understood interaction regulates order, duration and intensity of physiological processes in the organism (a good survey of the present state of research is given in Foster and Kreiman 2004).

In biological research, these rhythms are usually characterised in terms of chemical processes in various types of organisms, flowers, animals, human beings. But they bring us already somewhat closer to the properties of a person who actually experiences time – a notion completely absent in physical time. We find it, for example, in St. Augustine's notion of time as a property of our soul. His argument is entirely based on a very subtle but completely intuitive self-observation. Modern psychology has led to many insights into how time is perceived, remembered and transformed into human actions.

I. What is the *Now* that separates the past from the future and allows us to define what is present? This notion has vexed philosophers from Aristotle to McTaggart, for at least two reasons. First, it "shifts" permanently: there is not a single now, there are infinitely many nows. But there is always a special now – the now right now, so to speak. So, how is this now defined in contrast to all the other nows? Second, the "now" is supposed to have no extension, hence no duration (and in the sense of physical time, it is not in time at all: no duration, no time). If this is true, then there can be no present. But if there is no present, it seems to make little sense to speak of past and future. Arguments of this sort have lead to the idea that time is "not real", a position indeed taken by philosophers from the antiquity until to McTaggart. Now, rather than worrying about these puzzles, psychologists have tried to determine what the minimal unit of perception is, that is, the shortest time at which our sensory organs can, for example, distinguish a change in vision or audition. For human beings[6], this shortest moment is assumed to be somewhere between 30 and 40 milliseconds (Poeppel 1988). But already William Stern noted in 1897 that this shortest moment may not coincide with what we consider to be "present" (whose duration he calcu-

[6] The idea of such a shortest time span of perception and the possibility that it might vary across species was first introduced the founding father of embryology, Ernst Baer, in 1864. He also beautifully illustrated the dramatic consequences of this variation for the way in which the world is experienced.

lated as 6–7 seconds). This may not solve the philosophical problems connected to the now; but if the present is defined by what is perceived right now, then we know at least how long the now is.

J. How do we experience duration? The duration of some event or state is "objectively" measured by relating it to repeated occurrences of some other event (for example the heart beat or the rotation of the earth around its axis). As everybody knows, this measured duration of an event often sharply contrasts with the subjective duration someone attributes to it. This variation depends on many factors, for example

- the number of subevents – that is, changes we note within the entire period: if "nothing happens" within one hour, then this hour is subjectively much longer than when it is filled by many subevents;
- the degree to which we like the event: sadly, unwanted events seem to last much longer than events which we enjoy;
- the influence of drugs; some drugs "stretch" the subjective duration of an event.

We do not immediately perceive the relative order of events – succession always involves memory or expectation. This brings us to the second factor, the memory of time.

K. Time is closely connected to remembrance. But how do we remember time? This concerns duration as well as succession. In our recollection, the perceived duration of an event is sometimes reverted: idle hours, which did not seem to end, shrink in memory, events which excited our attention and seemed to pass rapidly, as they happened, tend to be very long in memory. If we try to recollect a complex event that we have experienced in the past – say a car accident –, how do we know that subevent A came before subevent B? And how do we record partial overlaps of subevents? In other words, how do we store the order of events, as we perceived them? In some cases, we might have looked at a watch and thus remember "A was at 10:15, B was at 10:16"; but this is surely the exception. Do we use an inner watch which allows us to stick a sort of "time stamp" on all subevents? Or do we just associate pairs of events by a relation "A before B" or "A simultaneous with B", thus eventually forming a complex temporal web of subevents? (see Kelly 2005 for a discussion and how it relates to various other time puzzles).

L. We not only perceive and remember temporal features of what happens in our environment, we also plan and perform actions. These actions often

consist of a complex structure of simultaneos and sequential subactions. Thus, they exhibit a complex temporal structure. In some cases, the temporal order in which subactions are to be performed are more or less dictated by the intended result ("first the socks, then the shoes!"); in other cases, this must be stored as an independent part of the planning ("first push the red button, then the black button"!). Jean Piaget, in his famous theory of child development (1927), argued that a great deal of this development is characterised by increasing abilities to decompose complex actions in subparts and to process and execute them independently; young children treat complex events holistically, as a unit, older children learn to separate and possible revert its parts. A particularly interesting aspect of the temporal composition of actions concerns the question of whether our "decision" to do something always precedes the action itself. One such subphase of a action concerns the decision to perform it: does this decision always precede the action itself? Benjamin Libet and others have shown that this may not always be the case – a finding which has led to considerable discussion on the notion of a free will (Libet 2004).

Humans are similar in some respects, and they are different in others. To what extent does this influence their notions of time? No one assumes that biological differences between individuals bear on the relative order of events, or the division of time into past, present and future. This is perhaps less true for duration: some people seem to be slow, others are fast, and this could be due to the fact that their inner clock runs at different speed. A good example is language processing; there is a number of verbal tasks in which women are on the average much faster. But this biological variation is minor, when compared to the variation in human cultures. In anthropological research, it is often assumed that different societies have developed quite different concepts of time. In what follows, we briefly discuss four examples which illustrate this variation (a very detailled discussion is found in Wendorff 1980).

M. Life in different cultures always follows certain "natural rhythms", such as the sequence of the seasons or the various ages of a person from birth to death. But the degree to which these rhythms dictate human life and thought varies considerably. Societies in which these rhythms prevail are often said to prefer a "cyclic concept" of time, in contrast to the "linear time", so familiar to us in modern Western societies.

N. A second, related aspect is the degree to which daily life and work are dictated by the mechanical measurement of time. Until a few centuries ago,

precise clocks and calendars were exceptional in any society; nowadays, they characterise the entire daily life of more and more societies (see, for example, Dohrn-van Rossum 1996). Note, however, that "mechanical clock time" is not to be equated with the notion of linear time; after all, clocks are based on cyclic events.

O. What role do history and chronology play in a society? All human cultures we know of have some notion of the forebears which may still be "present" in some sense – dead, but still an active force in daily life. This connection to the past may be structured in different ways. Some old cultures, such as the Chinese, the Japanese or the Egyptian culture, are bound to the remote past by an uninterrupted "chain of generations", for example dynasties or families. Others, such as the Greek or the Indian culture, also have strong ties to a very distant past, but they never have the notion of such a linear chain which connects the present to the origin (see Nakayama 1968).

P. Cultural variation in timing also surfaces in a number of phenomena which we find in all human societies. The most obvious example is *music*: in all its manifold forms, it is always a way to organise sounds in time – to organise their succession or simultaneity, as well as their duration. Music has its roots in our biological clocks; but the way in which it evolves varies massively across cultures (Jourdain 1999). Many other time-related human activities show the same pattern: there is an essentially universal biological root, and there is massive cultural variation – for example dance, poetry, and, of course, language.[7]

This brings us to our final point. There are at least four ways in which language is crucially connected to time. Languages *change in time*, they are *processed in time*, they exhibit a *linear order*, and they *express time*.

Q. In the antiquity and in the middle ages, the idea that languages change was not unknown; but this fact, obvious as it is, did not play a substantial role in the way in which philosophers and linguists thought about language.

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[7] Another interesting case are movies which present a complex event within a certain time frame, say 90 minutes; but the "real" time of the event thus represented is, of course, normally much longer. This can be used for special effects, such as in Buster Keaton's silent movie "Seven chances" in which movie time and depicted time converge, as the movie goes on.

This changed with the advent of historical comparative linguistics around 1800, and for at least a century, diachronic research reigned in the study of human languages. This research has bestowed a tremendous amount of empirical facts upon us, albeit only for a small number of languages. But in contrast to biological evolution, we are still very far from an idea of the principles that determine how human languages change over time (a good survey of the state of the art is Janda and Joseph 2004).

R. One of the miracles of human language is the speed with which it is processed in everyday communication. This becomes immediately clear as we look at a simple question-answer sequence such as: "Where were you born? – In Heidelberg". The person who answers has to identify the sounds, words and rules of the question in about one second, and it takes about another second to produce the answer. This includes the repeated inspection of something like 50,000 lexical items somewhere stored in the brain, but also the storage of the syntactic pattern of the question, the decision to use this pattern in the answer and to omit those parts which would be identical (the answer means "I was born in Heidelberg", and not just "in Heidelberg"), the innervation of a complex articulation pattern, etc etc. (Dietrich 2007 gives an excellöent survey of this research)

S. There are three major modalities by which human languages are encoded – speaking, writing, gesturing. Each utterance, each text follows a *linear order*, which is fundamentally temporal in nature. Linguists often say that a constituent "is moved to the left" or "to the right"; but in fact, this is only a spatial metaphor for the fact that this constituent is somehow processed at an earlier or later time when pronounced or written, heard or read.

T. Independent of whether a culture has a more or less elaborate theory of time – its members are always able to speak about time. They relate personal experiences, they talk about their future plans, they arrange dates, they describe how to bake a cake – all of this requires temporal notions of duration, succession and simultaneity. For a long time, the study of how temporality is encoded was completely dominated by two grammatical categories, tense and aspect, and a lexical category, called Aktionsart, situation type, or sometimes lexical aspect (Binnick 1990 gives an excellent survey of this research tradition). But this is only a selection of the means which natural languages use to express time; temporal adverbials are by far the most elaborate means. These devices will be discussed in the following chapter of this book.

This concludes our panopticum of time; it is easy to see that it is anything but exhaustive; but it surely suffices to give a picture of the diversity of time. Let us return to the initial question: What, actually, is time? If anything is clear by now, then it should be the fact there that is not a single notion of time. But it is also clear that the many facets of time are not an arbitrary collection of phenomena. There are a number of discernable threads in this clew, three of which will be addressed in the following section.

3. Three recurrent themes

3.1. Time and change

There is no immediate experience of time itself. What we experience are changes around us and in us. We see that it is getting dark and that it is getting light, we feel cheerful, and we feel sad. This experience is ubiquitous, and people have to adopt their life to it. But it was only the early Greek philosophers that began to wonder about two things. The first of these is a fundamental ontological problem: what does the pervasive experience of change tell us about the nature of reality:

- Is it steadily changing, as Herakleites is supposed to have thought? Among his cryptic sayings, *panta rhei* "everything is in flow" is probably the most famous.
- Is this impression of steady change fallacious, and reality is eternal and immutable, as Parmenides is reported to have thought?
- Do we have different types, or perhaps degrees, of reality – one of them characterised by change, the other one by non-change, as Plato and many others, notably the Neo-platonists, argued?

In this discussion of reality, two issues must be clearly kept apart: The first issue concerns the "reality of time": is time "real", or is it just a fiction of our mind. This question has led to vivid discussions, but mainly among philosopers; it is an interesting but somewhat academic problem. The second issue is the nature of reality itself: is there a reality – maybe the only "real reality" – behind the apparent changes, which our senses tell us? Different views which people have taken on this question had dramatic consequences in the history of mankind; the entire dogma of transsubstantiation, so fundamental to Christian faith, depends on the possibility that "real reality" is independent of apparent change or non-change, and many people have died for the one position or the other; so, it is probably an important issue.

The second problem, about which the Antique philosophers stumbled, is not ontological but epistemological. How is it possible that one and the same entity can have two mutually incompatible properties? How can someone be alive and dead, how can someone be in Athens and in Crete? The answer is that this entity has the same property *at different times*. Someone might be in Athens at an earlier time and at Crete at a later time. A difference in time need not lead to a change; someone can be in Athens at one time, and in Athens at a different – later or earlier – time. But it makes change possible – or, in a saying of unknown origin: "Time is nature's way of keeping everything from happening at once". Thus, time and change are closely connected to each other.

Changes can be of different sort, depending on the type of property at stake. There are, in particular

a) spatial properties, such as being in Crete and in Athens, being here and there, being under the blanket or on the blanket;
b) qualitative properties, such as being red and green, odd and even, immortal and mortal;
c) quantitative properties, such as getting a bit drunk or heavily drunk, driving seven miles or 99 miles, weighing one ton or nine tons. These properties are usually somehow derived, since they operate on qualitative or spatial changes and indicate differences in degree – either numerically or in a somewhat fuzzier way.

Accordingly, there a different types of changes – spatial, qualitative, quantitative. Any such change is a combination of times and properties. Motion, for example, is a change of spatial properties. Note that the property itself does not change, nor does the time change, although we often say this. What changes, is the assignment of properties to something, for example a person or an object, or perhaps to a full situation. If someone is alive at some time and dead at a later time, i.e., dies, then the property "be alive" does not change; but it so happens that that person does not have it any longer. Similarly, if someone grows from five feet to six feet, the properties "be five feet tall" and "be six feet tall" do not change; but the person has them at different times. And, of course, the earlier time is not all of a sudden a later time. In a word: neither times nor properties change; what changes is the assignment of properties to something over time.

The distinction between time and change seems an obvious one. But it has led, and still leads, to substantial confusion. In what follows, I will consider two examples that have played an important role in the discussion of

time. The first confusion concerns the notion of *irreversibility*, that is, the "arrow of time" discussed above (section 2, point E). The laws of classical as well as of relativistic physics apply equally from earlier to later and from later to earlier: time is "reversible". Biological time – and similarly the time of our daily experience – is orientied: it runs from birth to death, never from death to birth; it is "irreversible". But this common way to state the difference is misleading. It is not time that is reversible or irreversible but the sequence of changes. Take the simple case of a glass which, once broken, cannot return to the state in which it was not broken (and thus really a glass, and not a mass of pieces): we can image this, even see it on a film that runs backwards; but it is never observed in reality. But suppose reality would indeed allow this to happen – then, there is still an earlier state, in which the glass is not broken, and a later state, at which it is not broken, interrupted by a state in-between, at which it is broken: there is a temporally ordered sequence "not-broken – broken – not broken", each of which is associated with a different time: there are three different time spans, two of which – the first and the last – are associated with the same qualitative properties. The glass does not "return in time" – it has the same properties again a later time. So, the difference between "reversible" and "irreversible" is only whether we can have the sequence of changes "unbroken to broken" as well as the sequence "broken to unbroken", or only the former. But each of these two sequences goes from earlier to later. Even if the order of changes can go in both directions – time cannot: there is no irreversable time.

The second confusion concerns the notion of a *cyclic time* (in contrast to a *linear time)*. From the Greek notion of the "Great year" – a very long period after which everything is destroyed by fire and then reborn – to Friedrich Nietzsche's "ewige Wiederkehr des Gleichen" ("eternal return of the same"), many share in the view that the world passes through cycles of creation, destruction and recreation (the classical treatment is Eliade 1954). In anthropology, it is often said that some cultures or some schools of thought do not have the western notion of linear time: there are time cycles (Wendorff 1980). In linguistics, Benjamin Lee Whorf became famous because of his claim that the Hopi have a completely different view of time than the one found in "Standard European Languages", a view which does not see time as a linear sequence but as a cycle (see the critical examination in Malotki 1983). But in all of these cases, this does not imply that the *time* is cyclic. It only means that the same *sequence of changes* is repeated and thus cyclic. The experience of such change cycles is very natural, on a short scale, as the sequence or day and night, as well as on a larger scale, as the re-appearance

of certain stellar constellations. But this does not mean that the time itself comes and goes. We can count the repetitions. The seventh time, when the sun rises in the east, is not the same time as the twelfth time at which this happens. The twelfth time at which the world is re-created is not the fifteenth time at which it is re-created. What might be identical, are the properties which the world has at these different times.

Aristotle, to whom we owe the first systematic examination of time in general and of its relation to change in particular, states this very clearly in his famous definition of time: time is "a number of motion with respect to before and after" (Physics IV, 219 b 1–2). Aristotle's analysis of time is not easy to follow, and it has given rise to various interpretations (see, e.g., Coope 2005). But he not only makes a clear distinction between time and change; without such a distinction, it it would make no sense to say that something happens slowly or fast. He also characterises time as something that can be *counted*. If the entire world is reborn for the seventh time, then this seventh time is *later* that the sixth time at which it is reborn.

3.2. Time and its units

Is there one time, or are there many times? The common idea is that there is one time which can be subdivided into smaller units. These "smaller times" are called time spans, temporal intervals, subtimes, or just "times". We say that there is a time a which we met our first love, and a time at which we lost her or him, and each of these times it is a subinterval of the entire time; these subintervals themselves have subintervals: time is somehow nested. Several things can be said about these time spans:

1. They have a *duration*. We do not know whether the "entire time" has a duration. As we have seen above (section 2, point D) Newton equated absolute time with duration; but as soon as he talks about the measurement of time, only smaller time spans – for example the duration of some event – are at issue.

2. This duration can be measured. This is done by relating the time span, which is to be measured, to the duration of some other time spans; these are given by repeated occurrences of specific events (such as the rotation of the earth). We say that time can be measured. In a way, this is puzzling. When can it be measured? Clearly, time does not stand still during the measurement process – thus, the entity to be measured changes during this process. But there is no real puzzle: we do not really measure time, we measure the

duration of events, and we say that this duration is the time during which the event lasts. But one thing is the event, another thing is its time, just as there is a difference between a cup and the space which the cup occupies.

3. Time spans do not stand alone. They are related to each other according to an underlying earlier-later order which is unidirectional. But two time spans can also be simultaneous or overlap. In other words, time is a sort of structure whose units are time spans and whose structure is defined by temporal relations such as *succession, overlap, simultaneity*.

4. Each time span in turn consists of time spans. Does this go on forever – i.e., is there is "shortest time"? This is surely the case for human time experience. It is less clear whether nature has a minimal time span. Traditional as well as modern physicists assumed that *natura non fecit saltus* ("Nature does not make jumps", i.e., there is continuity). It was only in 1900 that Max Planck showed, quite reluctantly, that physicists are well advised to assume that there is a shortest time, whose duration is 5.4×10^{-43} seconds. We can, of course, *imagine* a shorter time, for example, 10^{-44} seconds; such a product or our mind is just meaningless for the laws of physics – and it would still leave us far away from a continuous time, which has no shortest interval.

5. Is there is a "last time span", i.e., does time have an end? And similarly, is there a "first time span", i.e., does time have a beginning? St. Augustine says no, Stephen Hawking says yes, Immanuel Kant says that both views lead to paradoxes. The reasonable person has no opinion on this issue.

3.4. Time and the observer

Neither physical time nor biological time, in the senses mentioned in section 2, know the distinction between past, present, and future – notions which everybody feels to be fundamental to human time. Einstein, in a conversation with Rudolf Carnap (around 1953), explicitly noted this fact: "Once Einstein said that the problem of the Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter of painful but inevitable resignation. I remarked that all that occurs objectively can be described in science; on the one hand the temporal sequence of events is described in physics; and, on the other hand, the peculiarities of man's ex-

periences with respect to time, including his different attitude towards past, present, and future, can be described and (in principle) explained in psychology. But Einstein thought that these scientific descriptions cannot possibly satisfy our human needs; that there is something essential about the Now which is just outside the realm of science. " (Carnap 1963: 37f.). This distinction between past, present and future requires an observer; this observer cannot be an instrument which measures time, such as a clock. No chronometer, precise as it may be, distinguishes past from future. To this end, an observer is needed who identifies a time span as "being now". Human beings are able to do that. Maybe other animals are able to do it as well, although this question is not easy to answer.

But what is the "now"? In the long philosophical debate on this question, there has never been an answer on which the experts agree. Essentially, there are two different though interconnected problems. First, there is not just one "now" but infinitely many – the "now" right now, the "nows" that before that, and the "nows" that are ahead of us. In other words, time itself seems to be a series of nows. Acccordingly, there is a past and a future relative to each of these "nows". But what distinguisthes the "now" right now from all other "nows"? It must be a special property which somehow comes from the particular observer who experiences the – inner or outer – world as somehow "present", whereas earlier nows are somehow in memory, and later nows somehow in imagination. But on the other hand, the earlier "nows" are also defined in relation to the experiences of some observer, perhaps the same observer at some earlier time; so, the problem cannot be easily reduced to the difference between memory, experience and expectation in our soul, as St. Augustine does. It appears, therefore, that the distinction between "now" and "not-now" is not reducible to any other difference. The second classical problem results from the fact that the now does not seem to have an extension; otherwise, it would consist of several moments, some of which are earlier and hence past, and hence not now. But if the now has no extension, it does not exist, and hence, there is no presence; but if there is no presence, there is neither past nor future. Moreover, it is not possible that the entire time is built up from a series of nows, because if they have no extension, time cannot have an extension, either. These are the type of mind-boggling problems that were extensively discussed from Aristotle (Turetzky 1999: 22–25) to our days (see, for example, Dummett 2000).

In the second half of the 19th century, physiologists and psychologists set out investigate the notion of "present moment" with experimental methods. From film watching, everybody knows that when the number of pic-

tures presented to our visual system exceeds about 20 per second, it cannot keep them apart and perceives them as a continous movement. So, there is a shortest time for (in this case visual) experience. But does this shortest time correspond to the "now" which underlies the distinction between past, present and future? When watching a film, or listenening to a tune, our intuition about what is on-going, rather than gone or only to come, seems much longer. So, there must be something in our brain which integrates shortest perceptual moments into a whole – a "perceptual present"; assumptions go that this perceptual present can last a few seconds.

Still a different issue is the "now" which underlies the linguistic expression of past, present and future. All languages in the world mark such a distinction by tense marking (*he is here vs he was here vs he will be here*) or by adverbials such as *yesterday, last year, very soon*. How is this now defined? Clearly, it cannot be the meaning of a word such as *now* (or its counterparts in other languages). These words refer to a time span with, as the case may be, considerable extension (*As a child, I was very religious, but now, I am not*). The word *now,* when uttered in a speech situation, refers to a time span which INCLUDES the moment of speech, rather to the moment of speech itself; the boundaries of this time span can vary. It seems to be this moment of speech which serves as an anchoring point, in relation to which present, past and future are defined. In fact, this picture is too simple again because the "moment of speech" is usually not a moment – surely not in the sense of the shortest time our brain can experience. We shall return to this problem in section 4. Two facts should be noted, however. First, this temporal anchoring to whatever the the "present moment" is usually considered to be fundamental to the expression of time in natural languages. Second, the temporal anchoring point may differ considerably from what in other disciplines is considered as "now".

4. The time concept of human languages

As we have seen in the preceding two sections, there are many notions of time, such as biological time, Newton's absolute and relative time, time as Kantian "Form der inneren Anschauung" and hence a necessary precondition of all cognition, subjective time, as influenced for example by drugs, and so on. These notions are interrelated in many ways, but they cannot be reduced to one concept: there are many. Is there a concept of time which underlies the expression of temporal relations in NATURAL LANGUAGES? Even this is doubtful. In most modern cultures, metrical calendar time plays

an important role, so important that we often take it for self-evident. Our life is largely organised around (or rather along) this time, and hence, there are many expressions which refer to it – like *in the year of 2007, two hours and thirty five minutes after noon on May 8, 1998*, and so on. But many cultures do not have such a concept of metrical time, nor the notion of one major event in collective history to which everything can be temporally related. Even in Western culture, the full elaboration of this system is fairly recent. The mere fact that people talk of "hours", "days", "years" and "the birth of Christ" does not mean that they have a concept of metrical time, with the birth of the saviour, or some other important event, as point zero. Until a few centuries ago, the concept of "hour", for example, just meant "twelfth part of the day", and if the day was short, like in winter, the hour was short, as well. A "day" is simply the time, when there is light, or the time from when people get up until they go to bed again, no matter how "long" this may be in terms of a mechanical or electronical clock.

Therefore, it seems reasonable to distinguish between various layers of time structure that are used in the encoding of time. There is something like a "basic time structure" on which the expression of temporal relations in natural languages is based. This basic time structure must cover basic relations between time spans, such as succession and simultaneity, but also the notion of a basic vantage point – the "now" of an observer. More differentiated structures, like calendaric metrical time, may be added, as cultures develop. It seems likely, although this is an empirical question, that such additional structuring is only expressed by more or less complex lexical expressions, whereas the basic time structure is most often expressed by grammatical categories and by simple adverbs.[8]

4.1. The "basic time structure"

4.1.1. The ingredients

What, then, is this "basic time structure"? This is not easy to say, because at most 5% of the world's languages are sufficiently well described; for all others, our information is very superficial and often based on bold comparisons with familiar languages such as Greek, Latin or English. Hence, we might simply miss important temporal notions encoded in same or even many languages. But such is the state of our knowledge. An inspection of

[8] The following discussion essentially follows Klein (1984), Chapter 4.

those languages for which our information is more profound shows that the following six characteristics are indispensable:

A. Segmentability: Time, whatever it is, can be divided into smaller segments – "time spans" or "temporal intervals".

As was discussed in section 3.3, there is a perennial debate among philosophers and physicists on whether this division can be infinitely repeated or whether there is some minimal "time quantum". I do not believe that the mind of the common language user has a standing on this issue, and in fact, I would not know of any criterion to decide whether we need infinite segmentability, if we want to describe the linguistic expression of temporal relations. Let us now turn to these relations between time spans.

B. Inclusion: If s_1 and s_2 are time spans, then s_1 may be included in s_2; this inclusion may be full or partial; in the latter case, we may speak of "overlapping".

C. Succession: If s_1 and s_2 are time spans, which are not (fully or partly) included in each other, then either s_1 precedes s_2 or s_2 precedes s_1.

It is usually said that time is linearly ordered. The way in which we have characterised succession here is somewhat weaker: there is a partial order on time spans: time spans can overlap. Again, it is an open question whether this partial order is based on some full order on "time points", which make up the time spans. We normally assume that there is some temporal progression within a time span, and a strict order on time points allows us to reconstruct this intuition in a straightforward way.

These three features allow a clear definition of the "earlier-later" asymmetry between time spans as well as simultaneity. Simultaneity can be full (two time spans completely coincide) or partial, if they partly overlap.

D. Duration: Time spans may be long or short in duration.

Duration, as regularly expressed in natural language, is not another name for time, as in Newton's definition. It is a property of time spans. It is typically indicated by adverbials, such as for *two days, rapidly, quite a while*. They do not necessarily describe objectively measured time. If we say *It took Shin quite a while to…,* then we may refer to very "objective durations", depending on whether we talk about drinking a coffee or finding a spouse.

E. Origo: There is a distinguished time span, which we may call "the time of present experience". Everything before that is accessible to us only by memory, everything later only by expectation.

This origo is the dividing point between past, present and future. As was discussed in sections 2. (points H. and I.), and 3.3, such an origo is not part of all time concepts; it plays no role in physical time or in biological time. But plays an eminent role in the linguistic encoding of temporal relations. The best-known case is the grammatical category of tense; in its classical understanding, tense situates some event in relation to the "deictic origo", which is given by the moment of speech – the linguistic variant of the time of present experience. But there are also many adverbials which are anchored at the deictic origo, for example *today*, *three days ago* or, of course, the word *now* itself; thus, *today* means "the day which includes the deictic origo". Remember, however, that the meaning of the word *now* is not to be equated with the deictic origo – it refers to a time span which contains the deictic origo, but can be much longer (cf. section 3.3). We can say, for example *Now, the average temperature is much colder than in the pleistocene.*

F. Proximity: If s_1 and s_2 are time spans, then s_1 may be near to, or far from, s_2.

This feature is much less discussed in the tradition than linear order, duration, or the existence of a "now". But it is regularly encoded in natural languages. Proximity and non-proximity in this (non-metrical) sense is exemplified, for example, by expressions like *soon* or *just*; it also sometimes shows up in tense distinctions, like "near future" vs "far future". Note that this concept of "temporal distance" or "remoteness" does not presuppose a concept of metrical time. Quite the opposite, it is not easy to capture the idea of proximity in this sense by metrical distance: *soon* can mean "in ten minutes", like *the meal will be served soon*; but it can also mean "ten months", like in *they soon got divorced again*.

G. Lack of quality: Time spans have no qualitative properties; they are neither green nor sweet, and they have no wheels and no spines. They are contained in each other or just after each other or or more or less close to each other, and they are long or short.

In the tradition, this feature shows up in the discussion about how time and change are related to each other (see section 3.1 above). The latter normally

relates to changes in qualitative properties or position, the former to the "pure structure", in relation to which such changes are perceived, imagined, or expressed. When we talk about time, then typically, some descriptive properties are *associated* with certain time spans – for example, we may talk about the time at which some event took place, or some state obtained. But we must carefully distinguish between an event or a state, and the time at which these take place or obtain.

4.1.2. A more precise definition

The usual way to give a precise definition to temporal relations is to interpret time spans as closed (sometimes as open) intervals of the real numbers; the "smaller than"-relation between real numbers is then used in the obvious way to define a partial order on the intervals (if $s = [r_i, r_j]$ and $t = [r_k, r_l]$ are closed intervals, then s is BEFORE t iff $r_j < r_k$). This procedure, whilst straightforward and elegant, is not sufficient, however. It provides us both with too much and too little structure. Under the assumptions made in 4.2, the Basic Time Structure does not include the notion of a metrical distance between time spans; the definition just sketched does not, either; but the underlying relation between "time moments", identified with the real numbers, does. It also makes the assumption that time is dense, i.e., that there is no smallest time span, an assumption which may be too strong. But these problems are perhaps not really harmful. It is much more problematic that some crucial intuitions are not captured, in particular the features "origo", "proximity", and "duration". Hence, we need "more" structure.

(a) The most straightforward way to account for the notion of "origo" is to identify it with the moment of speech; in fact, such a "deictic origo" is found in all human languages we know.

(b) It is less clear how one should capture our intuitive notion of (temporally) nearness. One might think to use the natural topology on the real numbers: the neighbourhoods of any real number r are exactly those open intervals to which r belongs. But this gives us by far too much: it gives us all environments, rather than the one which marks the borderline between "close" and "far". Our intuitive notions tell us that each time span has a "REGION" around itself, whose borders vary with context. The time of drinking a coffee is usually shorter than the time of finding a spouse, and so are the "regions" around these two time spans. Temporal relations between two time spans s and t do not only differ

according to whether s precedes t, follows t, or is (partly or fully) contained in t, but also according to whether it is "in the region of t". This region may be very wide, if t itself is "long"; but it may also be short. It may also happen that the region is lexically or grammatically specified.

(c) There is no such straightforward solution for the related problem of duration. The fuzziness of durational notions like *for a while, shortly, very much later* cannot be accounted for by metrical time, on the one hand, nor by introducing simply a "region" around time spans. In some cases, one can relate the relative duration of a time span, for example the time which some event takes, to the average time of similar events. For example, in *She rapidly drank a beer*, the time of this beer-drinking is related to the average time of beer-drinking and found to be shorter than this average time. But there are cases in which this does not work, like in *He slept for a while* as compared to *He slept for quite a while*. It is no surprise, therefore, that the meaning of these expressions is hardly ever precisely described.

The components of the Basic Time Structure are thus:

- an infinite set of time spans (leaving aside whether these are infinitely divisible)
- an order relation on time spans (BEFORE)
- a topological relation IN between time spans
- for each time span t, a distinguished time span which includes t – the REGION of t
- a distinguished time span, the ORIGO.

We may now define the Basic Time Structure as follows:

(1) The Basic Time Structure (BTS) is a structure [/R, $\{t_i\}$, $\{R_i\}$, BEFORE, IN, 0], where
   - /R are the real numbers, with the usual order relation <
   - $\{t_i\}$ is the set of closed intervals of /R, the "time spans"; $\{R_i\}$ is a subset of $\{t_i\}$, such that for each t_i, there is exactly one R_i which properly includes t_i (R_i is the REGION of t_i);
   - BEFORE is a partial order on $\{t_i\}$, such that: If $s = [r_i, r_j]$ and $t = [r_k, r_l]$ are in $\{t_i\}$, then s BEFORE t iff $r_j < r_k$;
   - IN is a relation on $\{t_i\}$, such that s IN t iff they have at least one element in common
   - 0 is a distinguished element of $\{t_i\}$, the ORIGO.

The Basic Time Structure is a sort of scaffold which allows us to define various types of temporal relations such as BEFORE, AFTER, IN. These relations obtain between two time spans, which I will call temporal relata. In *John left yesterday*, for example, one of the relata is the time of John's leaving, the other relatum is the time at which the utterance is made, and the relation is BEFORE. Other, much more complex constellations are possible. In what follows, I will first illustrate some characteristic relations[9] and then discuss the various types of temporal relata.

4.2. Temporal relations

Temporal relations obtain between two time spans: a first time span, which I will call THEME, and some other time span, which I will call RELATUM. The what follows, theme is marked by −−−−−−, the relatum is marked by +++++, and the region around the relatum by ( ); the linear order is represented by left-right arrangement:

a. BEFORE, i.e., the theme precedes the relatum properly:

−−−−−− +++++

b. LONG BEFORE, i.e,, the theme precedes the region of the relatum:

−−−−−− (+++++)

c. SHORTLY BEFORE, i.e., the theme precedes the relatum, but it is in the region of the relatum:

(−−−−−− +++++)

d. JUST BEFORE, i.e., as SHORTLY BEFORE, but the theme abuts the relatum:

−−−−−−+++++

In this case, the theme is automatically in the region of the relatum – more precisely, the final part of the theme; in principle, it is not excluded that the theme begins long before the relatum.

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[9] In all of these cases, the Basic Time Structure allows us to give precise formal definitions. For present purposes, however, it will be more useful to use diagrams that illustrate the various relations.

e. PARTLY BEFORE, i.e., a the first part of the theme precedes and the second part of the theme is IN the relatum (the region is irrelevant):

−−−+−+−+−++

f. INCL, i.e., the theme is fully included in the relatum:

++−+−+−+−+−+++

g. AFTER, i.e., the relatum precedes the theme:

++++−−−−−

Other relations, such as JUST AFTER, SHORTLY AFTER, LONG AFTER can be defined analoguously. Note that the relation IN has been split here into PARTLY BEFORE, INCL and PARTLY AFTER; if we want such a notion, it can be defined by the usual Boolean operations.

4.3. Temporal relata

When a temporal relation is expressed in some communicative situation, the two relata normally have a different functional status. One of them, for example the time of some event, is somehow "situated" in time; this is done by relating it to some other time span which is supposed to be given in the communicative situation and then functions as a kind of anchoring point. I shall call the former, the theme, and the latter, simply the relatum, respectively. The familiar grammatical category of tense exemplifies this functional asymmetry very well. It indicates, at least in its classical understanding, that some event is in the past, present or future – that is, it precedes, includes, or follows the moment of speech. Thus, in *John left*, when uttered in a particular communicative sitution, the time of John's leaving is the theme, and the moment of speech is the relatum. Basically, there are three ways in which such a relatum can be given:

– deictic, that is, it can be derived from the speech situation;
– anaphoric, that is, it is mentioned in the preceding context;
– calendaric, that is, it given by some important event in cultural history

Calendaric relata is of lesser interest here; they only differ in which historical event from the shared knowledge of the interlocutors is chosen as an anchoring point – the foundation of Rome, birth of Christ, the Hedjra, the beginning of a dynasty, etc. There is no language in which tense is linked to

a calendaric origin. But many languages have a rich system of adverbials with such an anchoring point.

4.3.1. Deictic relatum

The Basic Time Structure, as defined above, includes a distinguished time span, called there the origo, which plays a special role in the expression of time. What is the origo in a given communication? Typically, it is identified with the "moment of speech" or, as is often said, the "time of utterance". The latter expression is preferable, since the "moment of speech" is ususally not just a moment. Expressions which use this time of utterance as a relatum are usually called "deictic". The verbal category of tense, which is deeply rooted in the grammatical system of many – though not of all – languages is deictic: *He was singing, he is singing, he will be singing* place the time of some event, before, around, or after the time of utterance. But deictic relata also underly many adverbials. Thus, *three years ago* (in contrast to *three years before*) means "at a time which is three years before the time of utterance", and *yesterday* means "at the day which precedes the day which includes the time of utterance".

The deictic relatum is fundamental to many temporal expressions. But it also raises a number of problems, three of which I will briefly mention here. First, how long is the "time of utterance"? Does it include the whole interval during which an utterance is spelled out, is it only a part of the latter, or is it even longer? Sometimes, a shorter relatum is needed, for example when someone says:

(2) From *now*, it is precisely four seconds until *now*.

We also have the opposite problem, i.e., cases in which the "time of utterance" seems to go beyond the boundaries of a single sentence. Does a longer text, say a lecture or even a novel, have a single time of utterance or a different one for each single utterance of which it consists? In a sense, a coherent sequence of utterances – a text, be it written or spoken – is a unit, and it should have a single relatum. But then, it would be strange to assume that this relatum is, for example, the time at which the whole text was produced: What is then the utterance time of the Bible, or the first book of Moses? In these cases, the characterisation of the deictic relatum as "time of utterance" is clearly insufficient.

Linguistic systems most often evolve in spoken communication, in which speaker and listener are equally present. Then, time of speaking and time of

hearing collapse, and hence, there is no need to distinguish between the speaker's and the listener's origo. But in other communicative situations, there are clashes, for example in written language (or even in spoken language, when it is stored in some way). In this case, it is regularly the speaker's origo which counts.

The third problem with the notion "time of utterance" concerns possible shifts – i.e., cases in which it is not the origo (the time of present experience) which counts but rather some other time interval. Two such cases are usually mentioned in the literature. The first is exemplified by "vivid narration", like in the historical present, in which the speaker treats past events as if they were happening now. Somehow, the time of utterance is replaced by the time of actual experience; it is the latter which serves as relatum. The other kind of shift is introduced by verbs of saying and thinking, as in these examples:

(3) I thought: Now, I must change my life.

(4) Yesterday, my friend said: Shouldn't we go to Berlin tomorrow?

In these cases, it is not the origo of the real speaker which counts but the origo of the person whose thinking or speaking is being talked about.

4.3.2. Anaphoric relatum

Anaphoric relata are time spans which are given somewhere in the linguistic context. Their role for tense is disputed. In the literature, a distinction is often made between "absolute" and "relative" tenses; the former are purely deictic, whereas the latter also involve an anaphoric relatum. Some text types, for example narratives, are based on an chain of such anaphoric relata. As with all types of anaphora, there are three subcases:

1. The anaphoric relatum is within the same clause (intraclausal anaphora):

In (5), the initial adverbial introduces a time span, to which another time span in the same utterance is related:

(5) At six o'clock sharp, he switched the light off.

2. The anaphoric relation may go from one clause to another, whilst still being in the same sentence (interclausal anaphora):

(6) When the phone rang, he switched the light off.

In cases of this type, it is often said that "two events" are temporally related to each other. But note that the entire *when*-clause only serves to define a time span, which functions as a relatum. In principle, this is not different from the anaphoric relatum in (5), which is simply specified by a clock-time adverbial.

3. The anaphoric relatum may have been introduced in a preceding utterance:

This type of anaphoric temporal linkage is most import for text organisation. It is exemplified by well-known discourse principles such as "the principle of chronological order" which states that, unless marked otherwise, the time span of some situation described is after the time span of the situation mentioned in the preceding utterance.

A time span that functions as an anaphoric relatum for some subsequent time span may in itself be based on a deictic relatum. Compare the following two intraclausal anaphoric relata:

(8) Three weeks ago, he didn't have a penny.

(9) Three weeks before that, he didn't have a penny.

In both cases, the initial adverbial introduces a time span, say t_6 and t_7, respectively. In the first case, this time span t_6 is three months before the time of utterance, in the second, t_7 is three months before some other contextually given event. Hence, the time span is deictically given in (8) and anaphorically in (9). But in both cases, the time span functions as an anaphorical relatum of the subsequent time span – the time at which he had no penny. The fact that something is an anaphoric relatum of something else does not preclude that it is in itself deictically introduced. On the other hand, we may often get "anaphoric chains"; an anaphoric relatum is temporally related to a preceding one, which in turn is related to another one, and so on, and so forth.

5. Concluding remarks

The ability to talk about time is a fundamental trait of human communication, and all languages we know of have developed means to express time. But in sections 2 and 3, we have seen that time is not a uniform phenomenon. There are numerous concepts of time; they share some features, but they are also divergent in many respects. Which of these concepts underlies

the expression of time in human languages? There is no straightforward answer, for at least two reasons. First, we are not well informed about most languages of the world. Second, those languages we know seem to differ in what they encode and how they do it. One way to approach both problems is to start with a relatively simple "basic time structure", which covers the core notions expressed in same of the better-studied languages. In section 4, such a basic concept is defined. As need arises, it can be refined; it can also be simplified, if the language to be described does not use all of features of this structure. But may serve well as a point of departure.

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References

Aristotle (many editions)
350 BC *Physics*. Available at http://classics.mit.edu/Aristotle/physics.html.
Bruton, Eric
1993 *The History of Clocks and Watches.* London: Black Cat.
Butterfield, Jeremy (ed.)
1999 *The arguments of time*. Oxford: Oxford University Press.
Carnap, Rudolf
1963 *Intellectual Autobiography*. In *The Philosophy of Rudolf Carnap*, P. A. Schilpp (ed.), 1–84. La Salle, IL: Cambridge University Press.
Coope, Ursula
2005 *Time for Aristotle*. Oxford: Oxford University Press.
Dohrn-van Rossum, Gerhard
1996 *History of the Hour: Clocks and Modern Temporal Orders*. Chicago: University of Chicago Press.
Dummett, Michael
2000 Is Time a Continuum of Instants? *Philosophy* 75: 497–515.
Eliade, Mircea
1954 *Cosmos and History: The Myth of the Eternal Return*. Princeton, NJ: Princeton University Press.
Flasch, Kurt
2004 *Was ist Zeit?. Augustinus von Hippo, das XI. Buch der Confessiones*. Frankfurt a. M.: Klostermann.
Foster, Russell G. and Leon Kreitzman
2004 *Rhythms of life: The biological clocks that control the daily lives of every living thing*. London: Profile Books.

Fraser, Julius T.
1987 *Time – the familiar stranger*. Amherst: University of Massachusetts Press.
Fraser, Julius T. (ed.)
1968 *The voices of time*. London: Penguin
Fraser, Julius T., Francis C. Haber and Nathaniel M. Lawrence (eds.)
1986 *Time, Science, and Society in China and the West*. Amherst: University of Massachusetts Press.
Heidegger, Martin
1927 *Sein und Zeit*. Jena: Niemeyer.
Herder, Johann Gottfried
1784 *Ideen zu einer Philosophie der Geschichte der Menschheit*. Riga: Hartknoch.
Horwich, Paul
1987 *Asymmetries in Time*. Cambridge, MA: MIT Press.
Janda, Richard D. and Brian D. Joseph (eds.)
2004 *The Handbook of Historical Linguistics*. Oxford: Blackwell.
Jourdain, Robert
1997 *Music, the Brain, and Ecstasy: How Music Captures Our Imagination*. New York: William Morrow.
Kant, Immanuel
1781 *Kritik der reinen Vernunft*. Riga: Hartknoch.
Klein, Wolfgang
1994 *Time in Language*. London: Routledge.
Le Poidevin, Robin and Murray McBeath (eds.)
1993 *The Philosophy of Time*. Oxford: Oxford University Press.
Libet, Benjamin
2004 *Mind Time. The Temporal Factor in Consciousnes*. Cambridge, MA: Harvard University Press.
Lucas, John R.
1999 A century of time. In Butterfield 1999: 1–20.
Malotki, Ekkehart
1983 *Hopi Time*. Berlin/New York: Mouton de Gruyter.
McTaggert, John E. M.
1908 The Unreality of Time. *Mind* 17: 457–474. (Reprinted in Le Poidevin and McBearth 1993).
Nakayama, Hajime
1968 Time in Indian and Japanese thought. In Fraser 1968: 77–91.
Newton, Isaac
1972 *Isaac Newton's Philosophiae naturalis principia mathematica*. The 3rd edition, with variant readings, assembled and edited by Alexandre Koyré and Bernard Cohen. Cambridge, MA: Harvard University Press.
Paul, Hermann
1882 *Prinzipien der Sprachgeschichte*. 2nd Edition. Jena: Niemeyer.

Piaget, Jean
1923 *Le développement de la notion de temps chez l'enfant*. Paris: Presses Universitaires de France.
Poeppel, Ernst
1988 *Mindworks: Time and Conscious Experience*. Boston: Harcourt.
Prigogine, Ilya, and Stengers, Isabelle
1993 *Time, Chaos and the Quantum: Towards the Resolution of the Time Paradox*. New York: Harmony Books.
Reichenbach, Hans
1958 *The Direction of Time*. Berkeley, CA: University of California Press.
Richards, Edward G.
1998 *Mapping Time, the calendar and its history*. Oxford: Oxford University Press.
Savitt, Steven, ed.
1995 *Time's Arrows Today: Recent Physical and Philosophical Work on the Direction of Time*. Cambridge: Cambridge University Press.
Turetzky, Philip
1998 *Time*. London: Routledge.
Whitrow, Geoffrey J.
1980 *The natural philosophy of time*. Oxford: Clarendon Press.
Wendorff, Rudolf
1980 *Zeit und Kultur. Geschichte des Zeitbewußtseins in Europa*. Wiesbaden: Westdeutscher Verlag.
Westfall, Richard Samual
1983 *Never at rest. A biography of Isaac Newton*. Cambridge: Cambridge University Press.