Time, Actuality, Novelty and History

Some Facets of a Phenomenon Still Awaiting Comprehension

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Abstract

Time is a fundamental dimension of experience. The experience we have of time itself is a notorious source of confusion, however. It proves extraordinarily hard to distinguish between the objective and the subjective part of this experience. Evidence of this difficulty is the fact that, in the sciences, there are as many concepts of time as there are distinct bodies of knowledge. It depends on the phenomena a theory is accounting for which concept of time it works with. The concept of time appropriate to account for motion is not rich enough to account for life, the concept of time rich enough to account for biological life is too poor to account for conscious life. A classification of the sciences according to the definition of time implied renders a hierarchy of increasing experiential concreteness and decreasing formal rigour. The richer a theory's account of what we experience as time, the looser become its definitions. The higher the standards of precision in a field of theorising, the narrower becomes its notion of time. This trade-off throws a new light on reductionism. When looked at from the perspective of time perception, reduction to physical reality proves to abstract from an entire dimension of existence. The dimension disregarded by reductive methods is that of *actual* time as opposed to the dimension of *real* time.

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Time

"Time" is one of the most frequently used nouns in English. Since the meaning of a word is what its use amounts to, it should be an easy exercise to say what time means. Nobody, however, has mastered this exercise satisfactorily until now. Even though we all know what we are talking about when using the word "time", we run into serious difficulties when asked to say exactly what we mean.[1] Of course, there are clear-cut definitions of "time". Time is a well-defined term in the physical sciences, after all. The problem with terminological definitions of time is that they do not express what we mean when using the word in everyday speech. The more rigorous the definition from an operational or logical point of view, the more extraneous becomes its reference to what we experience as the flow of time.

The passage of time is one of the mysteries almost untouched by the progress of science. One can even say that its mysteriousness has grown with the advancement of scientific knowledge. The more secure its march, the more sceptical science grew concerning the objectivity of time's flowing. If this flow is something objective, how can it be measured? Flow implies motion. What is moving when time flows? With the flow of time we mean the movement of the present moment relative to the chronological order of moments. Motion implies speed. What is the speed with which the now travels along the chronological axis? In order to measure the travelling speed of the now, some reference point lying outside the 'moment-just-being' would be required. Moments lying outside the present moment are operationally inaccessible, however. Anything actual *is* present. Hence, there is no way of measuring the speed with which time passes. But that is not all. The speed with which time passes even seems to defy consistent definition.

The dimension of speed normally is meters per second (or whatever units measuring space and time are used). The points to which the flowing of time is relative are not points in space, however, but points in time. The dimension of the speed with which time passes is seconds per second: it takes one second for

[1] The words of St. Augustine, "What is time? if nobody asks me, I know, but if I want to explain it to some one, then I do not know" (Confessiones, bk XI, ch. XV,xvii), are as correct today as they were in his own day.

the now to shift one second along the chronological axis. When divided, these terms cancel each other. By dividing one second by one second we obtain the dimensionless value of 1. Thus, whatever we are going to measure and whatever the subjective impression of the speed with which time passes may be, this passage seems to be bound to have the dimensionless speed of 1. A dimensionless something of value 1 cannot be called a speed at all, though.

The definition of time as something that passes and is centred in the now is contained implicitly in use of the tenses and temporal adverbs in natural languages. The tenses of past, present, and future, as well as the semantic meaning of temporal adverbs like "now", "recently", "soon", "today", "yesterday", "tomorrow", etc. express the fact that the now is separating two different regions of time. The region lying in front of it contains the totality of events still to come, the region lying behind it contains the totality of events that are already gone. The grammar of the *tempora* past, present and future gives expression, moreover, to the fact that the now is ceaselessly travelling. In order to distinguish the concept of time implicitly defined by the use of this grammar from clock time, let us call it *temporal* time.

Clocks do not measure the passage of time but translate temporal intervals into spatial structures. On the basis of the fact that the passage of time is incapable of being measured by clocks (or whatever physical device), the concept of temporal time was criticised by Ernst Mach in 1883.[2] Mach argued that the concept of a magnitude incapable of being operationalised by measurement is not a physical but a metaphysical one. He pointed out, moreover, that the question whether time goes by is insubstantial for the reality physical theories deal with. Neither classical mechanics nor thermodynamics are changed in any way by how the question is answered. Mach's contention seems to hold even for present-day mechanics. Neither relativity theory nor quantum mechanics contain - let alone depend on - some notion of the *flow* of time.

Shortly after Mach's criticism, Betrand Russell submitted the grammar of tense to a logical examination.[3] He pointed out that sentences containing tensed expressions have unstable truth values. The sentence "Yesterday was Sunday"

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[2] Mach (1883), pp.236-41.
[3] See Russell (1903), § 442.

is true today, Monday, and was false yesterday. The sentence "Now it is night" is true tonight and will be false tomorrow morning. The truth value of the predicates "is present", "is past", "is future" changes with time. Now-ness is an indexical expression as is here-ness and as are the personal pronouns. The truth value of sentences containing "here", "there", "I", "you" may change with time, too. This change, however, is manageable by modal logic, since the truth value of such sentences does not change if the speaker does not move from the original place of utterance or if nobody else but the original speaker utters the sentence. In contrast, the truth value of sentences containing "now" or "today" changes without further ado. It changes spontaneously and irresistibly by the simple fact that time goes by.[4]

Sentences with spontaneously changing truth values are without prospects of scientific approval. Thus, even before Einstein called for a final blow against it, the concept of temporal time was under heavy attack in science. The Newtonian concept of "[a]bsolute, true, and mathematical time" that "flows equitably and without relation to anything external"[5] was going to split into three separate concepts. Since time's flow as well as the direction of time is inessential for the formulation of the laws of mechanics and the theory of mechanical clocks, "absolute and mathematical time" turned into simple *parameter* time t. Parameter time is the one-dimensional continuum of datable points. In parameter time, differences in time are reduced to differences in date. Parameter time is homogenous, i.e. without preferred direction, and thus reversible. The direction of time comes in with thermodynamics and the notion of entropy. The entropy of a closed system grows unidirectionally in the sense that an ordering of its states according to entropy renders an order according to date in the direction from past to future. Since the increase of entropy is a statistical law that cannot - at least until now - be reduced to basic mechanics, parameter time and *directed* time are not only different but may turn out to be incompatible notions of time.[6] The direction in which entropy grows has to be

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[4] As a remedy, Russell proposed to substitute the tenses by the relations"earlier than" and "later than". In a criticism that surpassed Russell's, McTaggart showed that this remedy is inept. See McTaggart (1908) and McTaggart (1927), ch. 33. For an intensive discussion of McTaggart's attack on the concept of (temporal) time as such see Franck (1994).

[5] Sir Isaac Newton's Principia (1687), translated by Florian Cajori, Berkeley: Univ. of California Press [6]1966, vol. I, p. 6

[6] It has been even put into question whether the direction of entropy growth is a property of time as such; see Price (1996).

clearly distinguished, moreover, from what we experience as the passage of time. The growth of entropy does not imply that there is something like the now which travels in the direction of this growth. Or, to put it differently, the notion of a *direction* leading from past to future does not imply the notion of past and future as *regions* of time. Talking of past and future as regions of time presupposes the existence of a moment that, by being actual, separates two domains of non-actual time. Since the distinction between actuality and non-actuality hinges on the notion of fully-fledged temporality, isolating the perplexities surrounding the flow of time requires us to clearly distinguish directed time from temporal time.

Thus, even before the advent of relativity theory, Newtonian time had fallen apart into three concepts none of which is reducible to one another. However, these three concepts fit into a hierarchical scheme whose principles of order are symmetry and symmetry-breaking. Parameter time is the most simple and most symmetrical concept of time conceivable. It is, like the continuum of points in a one-dimensional line, perfectly homogeneous, i.e., free from any preference of direction and heterogeneity concerning actuality. *Cause* and *effect* are perfectly equivalent in parameter time. Processes running in parameter time are thus reversible. In order to reverse them, nothing more is needed than the replacement of t by -t. As a dimension, parameter time is like another dimension of space. The way of representing a process in parameter time is its so-called trajectory: the sum total of the states the process runs through. Since no difference whatsoever is implied concerning actuality, this totality of states is represented as if the states existed side by side.

In parameter time, instants are ordered like the points in a straight line. There is no relation such as 'smaller than' or 'greater than' between them. Accordingly, talking of an instant being 'earlier than' or 'later than' another is purely conventional. Since there is no preferred direction of time nor any difference concerning actuality, the relations of 'earlier than' and 'later than' are perfectly symmetrical. Things change, however, when entropy comes into play. Entropy growth prefers the direction from past to future. With the transition from parameter time to directed time, the order of instants turns into an order like that of the real numbers. In contrast to the points in a line, the real numbers are ordered according to an inherent magnitude. Analogously, the instants of directed time are ordered according to a measure inherent in them. Thus, the transition consists in breaking the symmetry between the two directions discernible in the one-dimensional continuum of instants.

A characteristic example of an irreversible process is black body radiation. Black bodies absorb electromagnetic radiation of any complexity, the radiation they emit depends only on their temperature, however. The radiation absorbed and the radiation emitted are equivalent energetically, but divergent concerning structure. The reflection is oblivious of the colour of the incoming radiation. Colour means structure or, for that matter, order. In black body radiation, order is lost. Loss of order means growth of entropy. Processes enhancing entropy are oblivious of the causes that give rise to the loss of order. Processes of this kind are irreversible because the equivalence of cause and effect no longer holds.

The entropy law or, as it is called, the Second Law of thermodynamics is a universal law. Entropy growth is a fundamental characteristic of processes running in a world that is far from thermodynamic equilibrium. In such a world, reversible processes can exist only as limiting cases. In such a world, entropy decline or growth of order is not excluded, however. The entropy law is a statistical law allowing for islands of growing order in the ocean of increasing disorder. Each organism represents such a 'dissipative' structure, as the islands are called. Through enforced dissipation of energy - which means through enforced entropy growth in the environment - the self-organisation of structures exhibiting novel orders of complexity becomes possible. Self-organised processes are irreversible not only because causes are forgotten but because instabilities occur that lead to 'bifurcations' in behaviour. Bifurcations make behaviour inherently unpredictable. The symmetry break between the directions of time is fundamental, thus, for the emergence of phenomena such as life, novelty and information.[7]

The equivalence that is lost when parameter time turns into directed time is the equivalence of cause and effect. On the level of entropy and negentropy growth, cause and effect are no longer exchangeable. The question thus arises what kind of equivalence breaks down with the transition from directed time

[7] See Nicolis/ Prigogine (1989).

to fully-fledged temporal time. The answer is not straightforward since no well-developed theory of temporal time is available. The kind of equivalence that no longer holds at the level of temporality became indirectly clear, however, with the advent of relativity theory.

Relativity theory is a principled theory deducted from the absoluteness of the speed of light. With the absoluteness of the speed of light, simultaneity becomes relative to the location of the observer or frame of reference. If simultaneity is relative to that location, the now is relative to the frame of reference, too. Locations that are spatially distant or distinct with regard to relative motion will accordingly differ in time. If the now is the moment of actuality surrounded by regions of what is no more and not yet actual, locations that differ in time cannot belong to one and the same *actual* world. The world as actualised in the now is actual only in the realm of one and the same now. Unsynchronised 'nows' unequivocally belong to different worlds. Thus, temporality splits the universe into as many worlds as there are locations possibly occupied by observers[8].

Actuality

The symmetrical relation that turns into asymmetry with the transition from directed time to temporal time is the equivalence of *reality* and *actuality*. In relativistic space-time, time assumes its space-like character since relativity theory meticulously avoids any notion of actuality as a mode of existence . In time as the fourth dimension, the states of the universe differing in date are arranged as if they co-existed in time. Accordingly, space-time has been addressed as a 'block' universe, encompassing the totality of its states irrespective of any difference between past, present, and future.

In the context of relativity, the now and its travelling turn into a subjective impression to which nothing corresponds except itself. As is well known, Einstein even called it a subjective illusion - if, however, a stubborn one.[9] What

[8] The rigorous deduction of this result is due to Kurt Gödel. See Gödel (1949).
[9] Albert Einstein - Michele Besso, Correspondence 1903-1955, Paris: Hermann1972, p. 538

is less known is that Einstein was seriously concerned with the problem of nowness. The peculiarity of the now within the scientific world view was the topic of a discussion between Einstein and Carnap. "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 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."[10]

What Einstein resigned himself to accept as a matter of fact amounts to an existential threat to the social sciences. The social sciences, by being sciences of man, cannot acquiesce in the scientific non-graspability of the now. They cannot help, that is, accounting for the difference between actuality and non-actuality. Without distinguishing the time being from the time past or yet to come, it is impossible to talk of things such as learning, planning, decision and choice. Without temporal time there is no such thing as *understandable* behaviour. It is not before the equivalence of reality and actuality is broken that the concept of *rationality* assumes definite meaning.

The social sciences are condemned to dealing with the perplexities of temporal time. Moreover, they are bound to assume that the individual worlds of the members of society have a common intersection in actual time. People agree on the time being. However subjective the nature of actuality may be, it is of accountable objectivity at the intersubjective level. People agree upon living in one and the same actual world. Splitting this world up into as many separate worlds as there are sentient beings occupying distinct locations in space-time must somehow be prevented from becoming experientially effective. The now must somehow be extended, that is, it must make room for minute differences in simultaneity. Indeed, the now, as we experience it, is not a razor's edge. It spans a kind of interval[11]. The now we are living in is a 'specious' present, as

[10] Carnap (1963), p. 37

[11] This interval has a lower and an upper limit. The lower limit is due to the limited temporal resolution of sensory awareness. The smallest unit of time perception is about 30 milliseconds. Below 30 msec perception of the sequence of stimuli, below a somewhat smaller interval (varying with modality) perception of differences as such comes to an end. The upper limit of the interval experienced as the moment-in-being depends on the ability of focussing attention. The unit of duration that is experienced as a whole may last up to a few seconds. See Pöppel (1989).

William James phrased it.[12]

The extendedness of the present further enhances the perplexities surrounding the flow of time. It seems to imply that there exists some kind of 'time window' covering a stretch in clock time instead of being point-like. Such a window cannot exist in real time, however. If there were an open time window in real time, it would present a whole package of temporally different instants as being now. There would be an exact, instantaneous present and a 'sloppy', extended present. Within the sloppy present instants could be distinguished as being earlier and later. Moreover, the sloppy present would encompass instants that are already past or yet to come relative to the instantaneous now. A now that encompasses instants that are past or future is a contradiction in terms - as long, at least, as time is supposed to have one and only one dimension.

Depending on the notion of a specious present travelling at an undefinable speed, it seems small wonder that the logical foundations of the social sciences are shaky. Above all, it seems pointless to criticise their models as being restrictive. Only by fairly restricting its scope, can temporality be accounted for in theory. Since the problems of temporality have resisted resolution until today, it has only been by circumvention that they were prevented from becoming destructive. Circumvention has its price, of course. This price rises the higher the greater the safety gained by leaving the dangers aside. Thus, a trade-off can be expected to be operative between the level of formal sophistication of modelling in the social sciences and the scope of temporality accounted for by the models.

Such a trade-off can be observed indeed. The opposing extremes of formal sophistication in the social sciences are mathematical economics and historiography. Characteristically, mathematical economics and historiography are the opposing extremes concerning the scope of temporality accounted for, too. Mathematical economics restricts its account of temporality to the minimum possible. Typically, it abstracts from ignorance and uncertainty, change and discovery, hope and fear, novelty and news[13]. The

[12] in James (1890)
[13] Cf. Shackle (1958), p. 93.

grandest and most sweeping example of this heroic abstraction is the Walras-Pareto type of static general market equilibrium. The paradigm of this paradigmatic model is classical mechanics. Accordingly, the decisions leading to market equilibrium are conceived of as being reversible in this model. There is no false trading nor are there contractual liabilities resisting revision. The Walrasian process of 'tâtonnement' is a process of recontracting that does not end before the equilibrium conditions are met throughout.

Of course, mathematical economics is not restricted to general equilibrium theory. There is also capital and growth theory, both concerned with investment and expectations. However, even capital and growth theory assume that the dynamics of the processes concerned are smooth and differentiable throughout. There is no room for surprise or discovery in these theories, either. In order to account for risk and uncertainty, lacking knowledge about the future is turned into known probability distributions. Genuine ignorance, as well as true novelty are concealed behind a veil of probabilism.[14] Mathematically, time in economics is parameter time t. Innovation in the economic process is a conception appropriate to the economic historian rather than to the economic theoretician.

In contrast to time in economics, time in historiography is fully temporalised. The concept of time that historiography works with is the one defined implicitly by the use of tenses and temporal adverbs in natural language. It treats things as incessantly and irreversibly changing. The allowance for change is not even restricted to the present tense in historiography. Historiography accounts for the fact that the constitution of past and future consists in breaking the equivalence of reality and actuality. It accounts, that is, for the fact that the past and future exist only in the present representation. For beings living in the present, the past and future are only accessible through actual recollection or anticipation, respectively. We have no immediate access to whatever may be the reality of world states that have passed or are yet to come. Each piece of information about history, even documents, fossils, and the like, must be in the present in order to be available. Accordingly, all we know, or think to know, about the future is constructed from information available at

[14] For discussion and criticism of this concealment see Georgescu-Roegen (1971), p 121ff, Shackle (1990), part I and II, Loasby(1976), and Vickers (1994).

present. Since this availability is subject to temporal change, the past and future change with the time being as well.

The events whose course historiography is reconstructing carry two dates: the date of their real occurrence and the date of their actual reconstruction. Events that carry two dates cannot be ordered unambiguously in one-dimensional time. A good deal of historiography consists in reviewing, criticising and correcting former historiography. Since historiography has no immediate access to the process it describes, the course of known history is epistemologically encapsulated in the evolution of historiography. This encapsulation means that known history is a process embedded into another process. The processes reconstructed and the process of reconstruction run in different times. An evolution consisting of different processes running in different times is inconceivable in a one-dimensional continuum of instants. Historiography is working with a concept of time that is implicitly defined as having more than one dimension. Since historiography is mainly narrative, relying on the grammar of tense rather than on formalisation, this heavy epistemological implication has rarely been accounted for[15]. Characteristically, however, the implicature comes to the fore when we try to incorporate history into computer-based geographical information systems (GIS).[16]

In geography, the trade-off between formal sophistication and the scope of temporality accounted for becomes almost visible. There is a characteristic difference between historical geography and time geography. Historical geography is purely narrative. Time geography introduces time in a graphical manner.[17] Typically, time geography visualises sections of space-time by projecting them into 2D+t 'space'. This graphical representation becomes possible by reducing the differences between past, present, and future to differences in date. Time in time geography is parameter time t, and nothing more than parameter time t. Time geography depicts the states a landscape and its inhabitants are passing through by arranging them explicitly as if in another spatial dimension.

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[15] See, however, Salamander (1982).
[16] See Snodgrass (1992).
[17] The concept of time geography is due to Torsten Hägerstrand and the school of Lund. See Hägerstrand (1970).

Since time geography reduces temporality to strictly one-dimensional time, there is a sharp line separating time geography from economics. In economics, time may be treated as reversible, but it cannot be defined as strictly one-dimensional. Homo oeconomicus is a rational agent. As a rational agent, he or she is concerned not only with the present but also with the future. Since for humans the future exists only in the present imagination, the events which homo oeconomicus is concerned with carry two dates, too. The return on investment considered carries the date of the expected accrual as well as the date of the consideration performed. Moreover, the interval between the two dates has economic value. The further the date of the accrual lies in the future, the lower is the present value of the investment (other things being equal). This depreciation even has a market price: its name is the rate of interest.

Interest rates measure the market value that things lose by not being available at present. The rate of interest is the rate at which temporal distance is discounted. Discounting for temporal distance means to take goods and evils the less seriously the further they lie in the future. It means, to be specific, lessening the present value of a future good or evil *exponentially* with growing distance. Discounting at a rate of 10% means that the present value of a gain or loss expected after 20 years is only one-seventh, when expected after 50 years no more than 1/148th. Thus, discounting for distance in time has an enormous impact on what seems to be rational economically.[18]

Interestingly, though not surprisingly, the theory of interest has been the most controversial part of theoretical economics. It is the part which suffers most from the restricted concept of time. Nevertheless, it shows something remarkable about the meaning that time has in the social context. It shows that time has at least two distinct meanings in social life. There is the time-preference valued by interest. Interest, however, is not the only market price that time has. There is another such price; its name is wage. Wages measure the value of time used for labour. The value of the time valued by wages depends on its actual use. In contrast to this, the time valued by interest cannot be used actually since it is future and thus imaginary.

[18] It may even be questioned whether discounting for time is rational at all. It is discounting for time that makes it seem economically rational to deplete natural resources irreversibly. Only by lowering the effective discount rate massively will it be possible to turn our present-day economies into sustainable ones. See Franck (1992).

Thus, time has two different prices.[19] Wages measure the value of time worked, interest measures the value of time deferred. The longer the labourer works the more he or she is paid. The longer the time to be discounted, the lower the present value of the good or bad in question. The value of time measured by wages is positive. The value of time measured by interest is negative. Time, as it is valued by wages, is a scarce resource, whereas time valued by interest is neither scarce nor can it be called a resource.

Something having two prices means something different in social life. Prices inform about people's preparedness to pay. In expressing their needs and wants through preparedness to pay, people tend to be truthful. It makes no sense to lie in this language. Hence, having different prices means that time practically differs in meaning. Being prepared to pay interest means being prepared to pay for not having to wait. Being prepared to pay wages means to be prepared to pay for services that consume other people's time. The time bridged by credits and loans is future time, the time consumed by the production of useful services is present time. Interest measures the market value of time on the imaginary axis, wages measure the market value of time on the real axis. The fact that time has both prices means that both the imaginary and the real axis of time play an actual role in social life.

Novelty

One of the most striking traits of present-day economic development is the de-materialisation and disembodiment that the economic process is experiencing. Information processing is going to outdo the processing of materials. Information processing differs from the processing of materials in its being nearly immaterial and in its being bound to strict irreversibility. Economically, information means novelty. The economic point of information processing is the *surprise value* it yields.

[19] For the capital and distribution theoretic background of this statement see Franck (1992), ch. 3.

In the world of classical mechanics there is no such thing as novelty, let alone surprise. Anything to be learned follows from the initial conditions of the processes considered. In order to allow for something novel to happen, the dynamics has to become complex and non-linear. The non-linear dynamics of complex systems is a recent and rapidly growing field of research in physics. It is the dynamics of anisotropic, directed time. It allows to account for instabilities and bifurcations and, thus, for things not yet contained in the initial conditions of the processes modelled. As promising as non-linear dynamics is in physics and biology, as hard it proves to be incorporated into economic theory, however.[20] 'Information economy' is a subject still awaiting treatment by mathematical economics.

The non-linearity of the processes involved is not the only difficulty the hypothetical theory of the information economy is facing. Economically, information is linked to actuality. In physics and biology, the novelty of things can be reduced to novel structures and functions. In economics, the novelty of things has to be turned into surprise value in order to count. Surprise is a phenomenon not reducible to structure and function. It does not make its appearance as long as the distinction between actuality and non-actuality is disregarded. If physics is right in contending that this distinction hinges on subjectivity, surprise is a phenomenon presupposing subjectivity accordingly. If surprise is a subjective phenomenon, the surprise value is subjective, too. Hence, it may well be that information, as it counts in economics, cannot be accounted for without appropriately accounting for subjectivity.

When looked at from this angle, it is no wonder that we are so far from a concept of information capable of being generally consented to. We agree on living in the information age, but we disagree on how to define information. There are definitions, to be sure. The more precise they are, the more restrictive their scope is, however. The hierarchy of syntactic, semantic and pragmatic information is one of growing scope and diminishing precision in definition, again. We obtain a similar hierarchy when we classify the various definitions - or quasi-definitions, for that matter - according to the concept of time implied. At the level of parameter time, information means structural complexity. At the level of directed time, the definitions of information range from negentropy to

[20] For a pioneering venture into the field see Lorenz (1993).

what cognition is about. Finally, at the level of temporality, information becomes conceivable as surprise value. This hierarchy, too, is one of growing scope and diminishing precision. Structural complexity is precisely definable and, hence, operationale as algorithmic complexity. Negentropy has the same statistical measure as entropy. In order to define what cognition is about, second order statistics are needed already. Surprise value cannot be defined straightforwardly nor can it be measured directly. Surprise value is what satisfies curiosity; its measure is the subjective preparedness to pay: be it attention or money. It seems, thus, that information theory is itself subject to the trade-off between attainable formal sophistication and accountable temporality.

History

A general problem of the definition and measurement of information is the dependence on the context involved. Information is nothing intrinsic nor has it a measure of its own. Information is essentially relative, the reference of its measurement being some minimum or maximum with which the pattern can be compared. The reference minima and maxima themselves have unambiguous definitions in the simplest cases only. The minimum that algorithmic complexity refers to is the shortest algorithm that reproduces the pattern. The maximum to which negentropy is relative is maximum entropy. Both algorithmic complexity and negentropy are measures of syntactic information. Measurement of semantic information - if it is possible at all - involves cognition. On the level of cognition, the relation between reference complexity and measured complexity becomes recursive. In cognition, the information squeezed out of a stream of data depends on the structural information to which previous stages of the stream have been compressed. Cognition thus depends on memory. Because memory feeds on data processing on its own, the measure of information in cognition is second-order statistics.

The measure of pragmatic information consists of a combination of surprise and confirmation. Data flows consisting only of patterns never experienced before as well as data flows consisting of nothing but known patterns contain no useful information. The maximum of useful information lies somewhere between these extremes. The concept of memory implied in the notion of pragmatic information is dynamic. Surprise has the effect that memory changes, whereas confirmation reaffirms existing memory. In its higher forms, pragmatic information thus depends not only on memory but on memory management. Without control of memory change, behaviour instructed by pragmatic information remains limited to simple adaptation. In cognitive terms, pragmatic information processing is limited to simple recognition as long as memory change is not controlled by semantic forms of discrimination.

Semantic forms of discrimination pertain to the interpretation of data as *representing* something that is not contained in their pattern. In the computer paradigm, elementary discrimination of this kind is that between a constant and a variable. The interpretation of a data string as a constant means that it is taken as such, literally; while its interpretation as a variable means that it is taken as a pointer. On the level of human memory, another instance of such elementary discrimination comes into play. It pertains to the time represented by some informational content. It is the discrimination between actuality and non-actuality. This difference cannot be reduced to a more primitive one without giving up the notion of a memorable past of present experience.

Having a memorable past means more than being able to record, store and retrieve the informational content of experiences made earlier. It consists in the faculty of generating and maintaining a cognitive map depicting a lifetime and more. The consistency of a cognitive map depicting the history of current experience requires continuous update at its front edge as well as in its entirety. Pastness, presence, and futurity are dynamic properties. Each moment, a moment having been future until then becomes present in order to instantly disappear into the past. Each moment, the totality of moments that are still future move closer to the present. Each moment, the totality of moments already past recede further away from the present. Each moment, thus, a unique past and a unique future become actual. Since past and future exist only in actual recollection or anticipation, respectively, events that are past or future carry two dates: the date of their supposedly *real* occurrence and the date of their *actual* imagination.

As soon as past and future events show up in present awareness, the unambiguous chronological order of memorable and foreseeable happenings is lost. In order to re-establish an unambiguous order, a dating system making use of both the real and the imaginary co-ordinate must be introduced. The events surfacing in the present must be ordered according to the chronology of their real occurrence and according to the chronology of the re- or pre-actualisation as well. The totality of events making up the cognitive map of a memorable past and foreseeable future are thus ordered not in a linear but in a planar way. The cognitive map our history consists in is not one-dimensional but, at least, two-dimensional.[21]

The continuous update of the cognitive map-making which our history consists in is what generates the perception that time goes by. In order to localise the place of the now in the order of the memorable and foreseeable events, one entry of the two-entry dating vectors must be continuously adjusted while the other one must explicitly be kept unchanged. Thus, the field constituting time perception is ceaselessly changing in one dimension while it remains unchanged in the other one. It is ceaselessly changing concerning the co-ordinate of the place where recollection and anticipation are actually possible. It remains unchanged concerning the co-ordinate of the place where the events that can be remembered or anticipated really happened.

A simple and illustrative proof of our capacity to handle two or even more dimensions of time is our faculty of episodic recollection. Episodic recollection means recollection not simply of facts or events, but of sequences of events that make up a process. Processes of more than negligible length cannot be remembered instantaneously. Episodic recollection is an activity, hence, that takes up time of its own. An activity consuming actual time in order to reproduce processes running in another time encompasses two processes running in different times at the same time. Even though the constituent processes run in different time, the activity of episodic recollection does not lose its identity. An activity, however, that consists of processes running in different times at the same time amounts to patent nonsense - unless the time it occupies allows for more than a single degree of freedom. An additional degree

[21] For different lines of reasoning that lead to the same result see Dobbs (1972), Franck (1989), (1994).

of temporal freedom is tantamount to another dimension of time.

If we go further and try to recollect an episodic recollection itself, we can see that our capacity to handle higher dimensions of time is not limited logically but only energetically. It is very hard to nest processes imaginatively. Imagining a process that is embedded into another process demands effort and training. It is not limited to the first stage, however. Even the thought by which we make clear to ourselves what episodic recollection means consumes time. The thought of an activity, however, that consists in nesting an imagined episode in a process of active imagination is a phenomenon encompassing already three processes, each of which is running in different time. Of course, this thought represents twofold nesting only formally. Probably nobody is capable of the mental acrobatics needed to perform the nesting in full detail.

Conclusion

We are back to the question of how it is conceivable that time goes by. We see that this question has two parts. The first part concerns the very existence of the now and the cause of its travelling. The answer to this first part cannot be given at present. It has to await further progresses in the physical and life sciences. The second part of the question concerns the translation of the experience of time's flowing into consistent thought. The answer to this second part of the question consists in showing which seemingly self-understood habit of thought must be given up in order to make the specious present and the speed with which time flows conceivable. This habit of thought has been identified by now. It is the seemingly self-understood supposition that time has one and only one dimension.

As soon as a second dimension of time is introduced, the phenomena of the specious present and the speed of its travelling lose their perplexity. Since past and future are extend in an 'imaginary' dimension, the specious present may be extended in that dimension as well. As soon as events become possible that carry two dates without losing their identity, processes running in different times at the same time consequently become possible. With processes running in different times at the same time, the speed with which time passes becomes definable. The speed with which time passes becomes a regular kind of speed if it is measured in length of imaginary remembered time divided by real time taken up by the remembrance, using suitable units for measurement on both axes. In fact, the impression that time passes at a certain speed appears where a comparison is made between a sequence of remembered events and the sequence of the acts of performing the remembrance.

Disregarding a whole dimension is a very powerful means of abstraction. If it is correct that time, as we subjectively experience it, occupies more than one dimension, it becomes clear why the natural sciences are so successful in abstracting from subjectivity. In this case, the world is consistently and precisely reduced to physical reality when time is reduced to clock time. Without accounting for a higher dimension of time, unresolvable problems should arise, however, when conceptualising phenomena such as subjectivity, actuality and history. Accordingly, the logical foundation and methodological clarification of the social sciences should remain as dubious as it is at present, unless a higher dimension of time is explicitly introduced. Even the self-account of science should run into serious trouble if the dimensionality of temporal time is not appropriately considered. Science is reductionist in its methods, to be sure. The theory of science cannot abstract from temporality, however, as soon as some notion of the accumulation of knowledge, of paradigmatic shifts or of scientific revolutions becomes unavoidable. If temporality exhibits a higher dimension, the conflict between the logic of discovery and the psychology of research, the dispute between the theory and the history of science should persist until the time gestalt of the advancement of knowledge is reconstructed adequately.

Founding the historical sciences is not the only way of testing the hypothesis that historical time has more than a single dimension. There are more immediate tests as well. First, there is the famous proof of the "unreality of time" by McTaggart.[22] In this proof, McTaggart pretends to demonstrate that temporal time cannot exist for logical reasons. He shows that it is impossible to account for the spontaneous change of the truth values of predicates like "is present" or "is future" within a conceptual framework of strictly one-

[22] See footnote 4.

dimensional time. In this framework, he insists, temporal time cannot be defined consistently. On the basis that (1) time is one-dimensional and that (2) inconsistent concepts cannot denote something real, he 'proves' that temporal time is an illusion. Contrary to various claims to the opposite, this proof has not been refuted conclusively until today.[23] It leaves, thus, the question open whether the changing truth values become controllable in a framework accounting for a higher dimension of time.

A second way of testing the hypothesis that temporal time has more than a single dimension consits in measuring the fractal dimension of phenomena such as musical understanding. Musical understanding asks for representing the time 'gestalt' of the whole piece of music in actual time. The time gestalt of a sonata or a fugue exhibits a cascade of self-simular structures the fractal dimension of which can be measured by analysing the score or the phonographic record.[24] As soon as this fractal dimension proves to be higher than 1, the actual understanding implies the representation of a time gestalt that cannot be accounted for in simple clock time.

Finally, there is a quasi-empirical test of the hypothesis that can be performed by programming computers. In the case that historical time deploys another dimension, any piece of software enabling a machine to deal consistently with historical objects or to use conclusively the grammar of tense should contain a data model accounting for the higher dimension.[25]. It should not be possible to program a machine to do as if it had a recollectable past and a foreseeable future without implementing a temporal perspective in the data model that makes use of more than a single degree of freedom. In order to disprove the hypothesis, nothing more is needed than programming these capabilities without implementing a planar possibility locus of time.

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[23] See Franck (1989), (1994).
[24] See Hsü (1993) and Vrobel (1997).
[25] See Franck (1990).

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References

Carnap, Rudolf (1963), Intellectual Autobiography, in: The Philosophy of Rudolf Carnap, ed. by Paul A. Schilpp, LaSalle, Ill.:Open Court, 1963

Dobbs, H.A.C. (1972), The dimensions of the sensible present, in: J.T. Fraser / F.C. Haber / G.H. Müller (eds.), The Study of Time, Berlin: Springer, 1972

Franck, Georg (1989), Das Paradox der Zeit und die Dimensionszahl der Temporalität, in: Zeitschrift für Philosophische Forschung, vol. 43, no. 3, 1989

Franck, Georg (1990), Virtual time - Can subjective time be programmed?, in: Ars Electronica 1990, ed. by Gottfried Hattinger, Morgan Russel, Christine Schöpf, and Peter Weibel, Linz, 1990, vol. 2

Franck, Georg (1992), Raumökonomie, Stadtentwicklung und Umweltpolitik, Stuttgart: Kohlhammer

Franck, Georg (1994), Physical time and intrinsic temporality, in: Harald Atmanspacher / Gerhard J. Dalenoort (eds.), Inside Versus Outside. Endo- and Exo-Concepts of Observation and Knowledge in Physics, Philosophy, and Cognitive Science, Berlin: Springer, 1994

Georgescu-Roegen, Nicholas (1971), The Entropy Law and the Economic Process, Cambridge, Mass.: Harvard UP

Gödel, Kurt (1949), A remark about the relationship between relativistic theory and idealistic philosophy, in: Albert Einstein, Philosopher-Scientist, ed. by Paul A. Schilpp, LaSalle, Ill.: Open Court, 1949

Hägerstrand, Torsten (1970), What about people in regional science?, in: Papers and Proceedings of the Regional Science Association, vol. 24, 1970

Hsü, Kenneth J. (1993), Fractal geometry of music: From bird songs to Bach, in: A.J. Crilly / R.A. Earnshaw / H. Jones (eds.), Applications of Fractals and Chaos, New York: Springer, 1993

James, William (1890), The Principles of Psychology, New York: Henry Holt

Loasby, Brian J. (1976), Choice, Complexity, and Ignorance, Cambridge: Cambridge UP

Lorenz, Hans-Walter (1993), Nonlinear Dynamical Economics and Chaotic Motion, Berlin: Springer

Mach, Ernst (1883), The Science of Mechanics: A Critical and Historical Account of its Development, tr. by Thomas J. McCormack, Chicago: Open Court, ^{2}1902

McTaggart, John McT. E. (1908), The unreality of time, in: Mind, New Series, no. 68, 1908

McTaggart, John McT. E. (1927), The Nature of Existence, 2 vols., ed. by C.D. Broad, Cambridge: Cambridge UP

Nicolis, Grégoire / Ilya Prigogine (1989), Exploring Complexity. An Introduction, New York: Freeman

Pöppel, Ernst (1989), Taxonomy of the subjective: An evolutionary perspective, in: J.W. Brown, Neuropsychology of Visual Perception, Hillsdale, N.J.: Erlbaum, 1989

Price, Huw (1996), Time's Arrow and Archimedes' Point: New Directions for the Physics of Time, Oxford: Oxford UP

Russell, Bertrand (1903), The Principles of Mathematics, Cambridge:

Cambridge UP

Salamander, Rachel (1982), Zeitliche Mehrdimensionalität als Grundbedingung des Sinnverstehens, Bern: PeterLang

Shackle, George L.S. (1958), Time in Economics, Westport, Conn.: Greenwood Press

Shackle, George L.S. (1990), Time, Expectations and Uncertainty in Economics: Selected Essays, ed. by James L. Ford. Aldershot: Edward Elgar Publishing

Snodgrass, Richard T. (1992), Temporal databases, in: A. U. Frank / I.Campari / U. Formentini (eds.), Theories and Methods of Spacio-Temporal Reasoning in Geographic Space, Berlin: Springer, 1992

Vickers, Douglas (1994), Economics and the Antagonism of Time, Ann Arbor: University of Michigan Press

Vrobel, Susie (1997), Fractal Time, Huston: The Institute for Advanced Interdisciplinary Research