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Guest Commentary

The Nature of Time

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The nature of time can best be appreciated by developing the concept of time from Information theory.

Consider a discrete source of information consisting of a single binary channel which can take the value 1 or 0. Suppose the maximum speed with which it can change its state is one change per unit of time. Suppose that its physical dimension in some given direction is one unit of length.

In time 10t this source generates 2^10 choices or since Information (I) equals the logarithm to base 2 of the number of choices

$$I = \lg(2^{10}) = 10 \quad .$$

Therefore the source generates 10 units of information in time 10t. If we increase the size of the information source to 10 channels the physical dimension is increased to 10 units of length and in one unit of time the same amount of information is emitted. Thus in terms of information, time, and length are equivalent. But if time and length are equivalent this means that just as we should be able to increase or decrease length, so should we also be able to increase or decrease time. In other words increasing length is equivalent to time moving forward whereas decreasing length is equivalent to time moving backwards.

Now the suggestion that time can move backwards is surely a reductio ad absurdum as far as the argument is concerned; it seems to contradict a deeply held psychological experience that time is essentially different to length in that it is a dimension in which we are always moving forward. The solution to this conundrum lies in our faculty of memory for it is this which gives time its arrow for us. In projecting our own subjective psychological feeling about time into nature we are guilty of an anthropomorphism every bit as unjustifiable though as excusable as the geocentric anthropomorphism of the Ptolemaic system. This can be demonstrated by the following example. Consider an individual moving forward in time, certain physical changes are taking place in his body and certain memory traces are being made in his brain. We can summarize these processes by saying that information is being transferred from the environment into the object, which in this case is the individual concerned. The individual is conscious of the growth of memory traces because his consciousness has access to them, i.e. he can recall them at will, and he knows the past. The memory traces which are going to be put in his brain but which are not yet there, he does not have access to, he does not know the future. Suppose now that we can control the physical processes that govern the growth of his

body and the input of memory traces to his brain and suppose we reverse those processes so as to return both his body and his memory to an earlier state. It is evident that he would have no knowledge of this reversal of his time because he would have no access to the information that had been taken out of his memory and put back into the environment, in other words he would have no knowledge of his future.

It follows that we can never be conscious of a negative movement along our own personal time scale any more than we can turn round in relation to ourselves. This is because our personal time scale is a conscious time scale and it is from this time scale that we obtain our impression of moving forward in time. If we could not recall the past in any respect we would have no consciousness of time flow. Also if we could call up knowledge of past and future with equal facility we would have no consciousness of time flow either.

To return for a moment to the individual who was moved backwards in his own time scale by reversing his physical and mental processes, it is clear that during the period that he was moving backwards in his conscious time scale we were moving forward in ours. We may therefore think of our time scale as superior to his since his time scale shows a reversal with respect to ours but our time scale shows no reversal but rather a forward jump with respect to his. We would be in a position where we could predict his future (assuming his environment to be reasonably constant) and he would no doubt regard us as a prophet in much the same way as a primitive savage would regard a man who could predict eclipses of the sun a prophet. As far as we are concerned we are not prophesying but only saying what for us has already happened; however, as far as he was concerned, we would be. Now all prediction in science is based on this ability to know what will happen in the future because in our superior time scale it has happened already. To say that a process is periodic or repetitive is to say that its time scale is inferior to ours. Without periodic or repetitive processes prediction in science would be impossible.

It is paradoxical that we think of the pendulum as a time measuring instrument when the only time it can really measure is that elapsing between the top and bottom of its swing. In fact of course, the pendulum is only one of the elements we employ in a device to measure time. The other element is a counting instrument of some kind, a clock mechanism, for example or a heap of stones and a jug into which we put a stone every time the pendulum swings. The essential nature of the counting device or memory can be assessed if we consider what would happen to our measurement of time if every occasion we dropped a stone into our jug the previous stone dropped through a hole and was lost.

Any reversible or cyclical event therefore is a process which involves the ebb and flow of local time. First we may consider a particular example of this and then a general statement which applies to all cases.

The swing of a pendulum involves an exchange of energy between the pendulum and the field. During the upward swing energy is flowing from the field into the pendulum. During the downward swing the reverse process occurs, the energy flows from the pendulum into the field. Relative to the pendulum the field energy (which is kinetic energy of the field particles) is potential. Relative to the field the pendulum kinetic energy is potential.

Now forward flow of time may be identified with increase in potential energy. Therefore during the upwards swing of the pendulum, time for the pendulum is moving

forwards. During the downwards swing, time is moving backwards. The reverse situation holds for the field.

The general statement of which the pendulum case above is a particular example is as follows:

Any cyclical process involves the exchange of information between an object and its environment. During one part of the cycle information is flowing from the environment into the object and time is moving forward for the object but backwards for the environment. During the remaining part of the cycle information is flowing out of the object into the environment and time is moving backwards for the object but forwards for the environment.

Thus time is the change in information dI and since for a change in a closed system a + b:

$$dIa = -dIb$$

therefore

$$dIa + dIb = 0$$

$$dta + dtb = 0 \quad ,$$

i.e. in a closed system, time is conserved.

The failure to recognize the complete symmetry between the object and the environment and the consequent conservation of time is just another case of the failure to recognize the importance of the denominator term for observer or environment.

At this point it is useful to return to the pendulum example and consider the hierarchical time scales which are involved in time measurement. The time of our pendulum is ebbing and flowing between zero and N the number of elements in the swing of the pendulum from its highest to its lowest position, whilst the time of our counting device is moving forward. Eventually, because the mechanical device is finite, the jug becomes full with stones or the hands of the clock point to 12, the time of our mechanical device returns to zero. In the case of the jug, which we shall suppose is emptied out and of the clock, the time jumps back to zero and does not return gradually to zero as the pendulum time did. If we want a time scale that continues to move forward we have to introduce a counting device in a superior hierarchy for which time goes forward and by which we can record the number of jumps or returns to zero, a calendar for example. This process can be extended indefinitely. It can be seen therefore that measurement of time interval does not depend upon one hierarchy but on a whole series of hierarchies. Furthermore, the hierarchical scales which we use to determine time do not bear a constant relation to one another; for example, on earth in 2003 the relationship between the day and the year is about 365. However, this is not so on the moon, nor will it be so on the earth in the very distant future.

Of course, it could be argued that although in practice we use hierarchical scales to measure time we do not need to do this in principle. We could just as easily count the most rapid event available and use this count as our measure of time. However, it can be shown that this notion is just not true. We do have to use hierarchical scales to measure time and we can never guarantee the constancy of one hierarchical time scale in relation to another.

Consider the time interval 9 years, 3 months, 2 weeks, 3 days, 1 hour, and 5 seconds. Now as has been pointed out these hierarchical scales do not bear a constant relation to one another. Surely we can get over this by eliminating the hierarchical nature of the statement and expressing the interval all in a single hierarchy in seconds;

293,418,005 in fact. Though we are not used to dealing with time intervals in figures looking like the national debt, presumably we could soon train ourselves to. We have surely established that though we do use hierarchical scales for convenience we do not need to do so. However, 293,418,005 seconds is expressed in hierarchical scales. Not scales of seconds, hours, days, weeks, months and years it is true, but instead scales of seconds, tens of seconds, hundreds of seconds, thousands of seconds, ten of thousands of seconds etc and these are just as much hierarchical scales as seconds, hours, days etc.

If we really wanted to express the time interval in some non-hierarchical way we should have to express it by a number thus 1111111111... i.e. involving 10^9 marks on paper. Such a mode of expression would be completely incomprehensible unless we adopted some implicit hierarchical structuring such as the number of pages of 1's, the number of books containing a certain number of pages each etc. The numbers of items we can comprehend without some implicit hierarchical structuring of this kind is no more than about 7 and even for 7 and smaller numbers there is probably some hierarchical structuring taking place at a subconscious level.

Suppose then it is accepted that even when we measure in seconds we do in fact measure time in hierarchical scales. Surely, however, there can be no question of the scales not bearing a constant relation to one another. After all ten units are always 10 and ten tens are always 100. In the conceptual numbering hierarchical system this may be so since we have a complete control of the system and can make the hierarchical relationship constant by definition. However, any physically realizable system of measuring time will consist of some hierarchical arrangement of counting devices and since we do not have complete control over the present, let alone the future, physical environments, we cannot guarantee that the relationship between one hierarchy and another will remain constant.

Suppose we consider a particular example of a physically realizable system for measuring time, a pendulum say, with a hierarchical counter resembling an odometer, i.e. consisting of several toothed cogs with one turn of the first cog producing 1/10th of a turn of the second cog and so on. Now over a short period of time the relationship between the movements of the cogs will be constant just as the relationship between the day and the year is constant over a few centuries. As the counting device wears out a point will be reached that the mechanism slips one tooth say and eleven turns are needed to operate the decade counter instead of ten; the hierarchical relationship has thus altered. In general therefore the relationship is not constant. Any physically realizable measure of time is hierarchical and the hierarchies do not bear any fixed relationship to each other. Precisely the same lines of augments can be set out for measurements of length to show that measurements of length are hierarchical and do not bear constant relationships to each other either.

The eminent English philosopher Berkeley pointed out centuries ago that physically unrealizable systems had no place in physics and one would have thought that by now his contention would have been accepted as sine qua non. In the event it appears to be just as difficult to exorcise magic from science, as it is to exorcise it in other places.

The trouble with moving away from primitive measurements of length and time such as the barleycorn and the foot, the day, and the year, and going to methods which are somewhat more constant is that we are deluded into thinking we have solved the

problems relating to hierarchical scales. In fact we do not solve them this way at all, but merely push them into the background where they are more difficult to see.

If we return to more primitive methods of measuring time and length we will appreciate that the notion that time and space are simple entities or simple concepts is illusory. They are as complex as the world they describe. Likewise the notion that time and space are one and three-dimensional respectively is also illusory. The dimensionality of any concept or physical entity is merely a reflection of the hierarchical level from which we are viewing it. Space has as many or as few dimensions as we wish to give it, and so has time.

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