Laws of Physics and Ideas of Time

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In this paper I shall try to discuss time in nonmetaphorical language, and explore the contribution that physics can make to such a discussion. I take metaphorical language to be language that is not forced upon us. As Professor Lawrence shows in his paper in this volume, the metaphors of time serve us like a fly's many-faceted eye, bringing not the clarity of focussed sight but the largest possible area of awareness. Where there is no choice of language, where we know only one way to say something, then from some higher point of view it may still be a metaphor but we experience the situation differently, and I am inclined not to use the term.

I wish to formulate a nonmetaphorical definition of time that arises out of my experience as a physicist, an almost trivial definition out of an almost trivial subject, and then show that in following the path of inference we find that even such a beginner's trail leads into unexpected rocks and swamps. If I use only the simplest language, it is because I do not know how to use any other and convince even myself that I am making sense. The spirit in which I approach the problem of definitions is this: any definition that links words with experience is full of mysterious assumptions that flash and rattle and clank round us like a hostile army in the night. The most we can do is to remain awake and not take unnecessary risks. When all else fails we can comfort ourselves with the maxim of the Dutch physicist H.A. Kramers: "My own pet notion is that in the world of human thought generally, and in physical sciences particularly, the most important and fruitful concepts are those to which it is impossible to attach a well-defined meaning."

I. A DEFINITION AND ITS CONSEQUENCES

To formulate a definition of any concept that refers to our experience we must start by finding some assertions about it that we must all admit to be true. For example, the American poet T.S. Eliot has written that "April is the cruellest month." One may discuss this statement from several points of view, and it has been done, but one is not obliged to make such a statement. One is obliged to admit that April is the month that follows March. What must we admit about time? Useless to assert that time is "the moving image of eternity" or, in its American equivalent, "the river I go a-fishing in." These are poetic assertions full of truth but not to be taken literally, and in addition, all ideas of motion or flow require a prior concept of time if they are to be explained nonmetaphorically. The trouble here is that although we perceive events, we do not perceive time; it is an intellectual construction used to give us a language with which to deal with events, to interpolate between them and extra-
polate from them. It is strongly influenced by linguistic and cultural conventions. In fact, I can think of no statement describing our experience of time whose truth must be admitted.

At this meeting of the Society we are intent on enlarging our comprehension of how man deals with problems of time. It is this concept that for this week of our lives organizes our thoughts on life, art, science, and the human personality. But the approach that my training forces me to follow forces me to adopt a definition of time based on publicly verifiable fact, even if it is a fact that lies rather far from our central areas of concern. I start with the fact that events in the universe of our direct physical experience require at least four numbers to identify them. Consider an event such as the arrival of a telegram. In this case, the four numbers serve to specify the place and time of its arrival. If one seeks to specify the event in some other way — to say it is the telegram that announced my brother’s wedding, that can be done, as the telegraphic apparatus does it, by giving other numbers, but many more than four of them. Most events require more than four numbers to specify them, but it is a fact of experience that we cannot make do with fewer. There is no reason to think that there is anything arbitrary or man-made about this number four. It is datum of experience.

Three of the numbers refer to location in space and one to location in time. It will be a proud day for physics when it can explain why there have to be four numbers rather than three or twenty. Of the four, we can identify the time dimension because of the permanence of objects, including our own bodies. Their extension in time is of quite a different kind from their extension in space. An object ordinarily occupies a definite position in space but not in time, unless it is like some short-lived atom that explodes the moment it comes into existence. Thus, the definition: Time is the dimension in which duration occurs. In writing this I wish to avoid a logical circle by assuming that the experience of duration, of the permanence of our bodies and of most of the objects around us, is an element of our wordless primitive existence. In her paper in this volume, Professor Green deals with experiments that show how children become aware of permanence and change before they have learned to speak.

If we pay attention to this fact which distinguishes time from the other dimensions we can save ourselves from those errors of analogical reasoning which run as follows: I am physically concentrated in a small region of space that I can call “here.” By analogy, I must also be concentrated at some small interval of time which I call “now” (the technical term for this interval is the “specious present”). Since it is fairly obvious that solid bodies are extended in time in a way quite different from the way in which they are concentrated in space, many thinkers specify that this “now” manifests itself in or to our minds; how this is possible for the mind but not for the physical brain of which the mind is a function is considered to be a substantive but unanswered question.

If one gets used to imagining one’s position in time as a point or small region analogous to one’s position in space, one begins to ask what happens to this point. Here again the spatial analogy offers its treacherous aid: the “here” of our bodies moves from place to place in the course of time; therefore, by analogy our “now” must also change with time: the present advances towards the future. As time goes on, time passes, or vice-versa. The fact that as far as I can tell, such a formulation is devoid of logical consequences, is unsupported by what we know of physics, and does not seem to be universal in human cultures does not prevent its wide acceptance as a starting point for what purport to be factual discussions about the nature of time.