British Journal for the Philosophy of Science, 17 (1967), 323–6.

REVIEWS

Basic Concepts of Measurement. By Brian Ellis.
Cambridge University Press, 1966. Pp. 220. £2 5s.

MR. ELLIS has written a long-overdue book on concepts of measurement, which to some extent collects and unifies work he has published in separate articles during the last few years. He starts by considering the general notion of applied arithmetic, and then turns to those applications of it that are involved in measurement. He deals first with the concept of a quantity, then with that of a scale, and with the classification of scales. He goes on to propound a classification of measurement into fundamental, associative and derived, and draws from this an analysis of numerical laws, units, and dimensions. Finally he discusses the concepts of number and probability conceived as quantities. There follow a number of appendices, of which the most important is a translation of the passage in Mach's *Die Principien der Wärmelehre* dealing with the concept of temperature as a quantity. There is a good bibliography and an adequate index.

The most valuable feature of the book is its range and generality. There has been a good deal of disjointed work on the problems of measurement in particular sciences, into which distressingly unexamined general assumptions tend to be imported. Quite how a subject so fundamental has contrived to become treated in general as at once trivial and dull is one of the mysteries of current philosophy of science. Mr Ellis will deserve our especial gratitude for having rescued it from this state, as his book surely must. There is no doubt that it will start a considerable controversy, for his analyses certainly raise as many questions as they answer, as he would probably admit.

I think it must be a principal complaint against Mr Ellis that he does not push most of his analyses far enough. His explications are too vague and, having exposed a problem, he is too content to leave it with an appeal to such barely analysed intuitions as that of simplicity. Simplicity is a notoriously complex notion, which Mr Ellis treats far too imprecisely for his repeated invocations of it to be more than plausible. There is not space here to do more than justify by selective illustration the claim that Mr Ellis's valuable analyses are yet open to important criticism.

For example, in discussing the concept of quantity in Chapter 2, well rehearsed objections to Dingle's operationalism are produced somewhat repetitively. Mr Ellis's important point is that a quantity is defined by the order of items possessing it, not by any one of the different linear ordering relations that can generate the order. It follows that quantities, like other scientific concepts, are cluster (indeed law cluster) concepts. It is a pity that

Mr Ellis does not bring this more explicitly into the definition of ' quantity '. ' Quantity concepts are usually cluster concepts ' (p. 35) is too weak. We just do not admit quantities unconnected by our law network with other quantities.

Mr Ellis's other emphasis in this chapter, on the relational character of concepts, does not seem to me well placed. The general analogy with velocity is unsound. A single object A in the universe has no determinate velocity because there is no other sufficient set of objects, B, to which its motion can be referred, not because there are also no measuring rods and clocks, or no objects going faster or slower than A relative to B. To invoke such latter requirements in 'denying that it makes any sense to speak of a universe consisting of a single object possessing a variety of different quantities ' (p. 38) is to relapse again into operationalism, and to forget that a quantity is a disposition, which does not need to exhibit itself continuously or in any one particular way. Now it may be true that the possession of some quantity, e.g. the mass of a body, is determined by the distribution of other bodies in the universe, but if so, that is a quite different, contingent, fact, not at all supporting the claim that all quantities are necessarily relational.

The discussion in chapter 5 of the problem of why ' we choose the fundamental measuring operations that we do ' (p. 82) seems to me to be needlessly laboured. Mr Ellis admits that our notions of appropriate measures grow out of pre-theoretical practices, such as counting steps between places to measure distance. ' But this is only to explain our feeling [that the measure is appropriate], not to justify it ' (p. 82). What sort of justification other than explanation is Mr. Ellis looking for, given his own earlier criterion (of the correlation of different measuring operations) for the existence of a quantity measured? Surely the explanation affords a perfectly good justification for saying that what we now have is a measure of the pre-theoretical notion of distance. That is the natural consequence of agreeing with Mr Ellis's denial of a direct, absolute, measure-independent intuition of what a distance is, not that a further justification must still be given, through vague invocations of simplicity.

Mr Ellis's remarks in chapter 7 on the age of the universe have again a *prima facie* plausibility, but really need rather deeper analysis. In taking the questions,

' (*a*) Is there a theoretical maximum to the age of an event as determined on any given scale?

(*b*) Was there an event before which no other event occurred? ',

to be separable, Mr Ellis must suppose that the term ' event ' can be used meaningfully independently of a choice of time scale on which events can be located. He may be right, but it is not at all obvious, and no arguments are presented to support such a view.

In chapter 10, one distinction between numbers and other quantities seems to me to be overdrawn. On page 155 Mr Ellis points out that the meaning of the sentence 'this group contains four things of such and such a type' is independent of counting operations. But equally, though perhaps not similarly, by Mr Ellis's own acceptance of quantities as cluster concepts, the meaning of 'this object is four metres long' is independent of any one particular method of length measurement. 'Our counting procedures are admitted as counting procedures, if and only if they give correctly the numbers of things in groups' (p. 155). Quite so, and the same is true of any proposed measuring procedure for length. No doubt with length it is a matter of correlation with other such procedures, which is perhaps not the case with counting. But anyway the point wants making more clearly than Mr Ellis makes it if he is not yet again to appear to be relapsing into operationalism.

Finally, despite his ingenious analysis, Mr Ellis does not persuade me in chapter 11 that there is a parallel between logical probability and a sort of 'logical' temperature. Let us follow recent literature in reserving the term 'chance' for the physical property which is the subject of statistical probability statements. Then the parallels to Mr Ellis's temperature statements,

T_i: 'The well-calibrated thermometer M has been immersed in the liquid L and the temperature reading t_i°C has been obtained' $(i=1,2,\ldots,n)$ and

S_T: 'On evidence $T_1, T_2, \ldots T_n$, the temperature of L is $\bar{t}_n$°C' where $\bar{t}_n$ in some average of $t_1, t_2 \ldots t_n$.

are the chance statements,

C_i : 'A representative sequence of M trials on the coin-tossing set-up L has been made, and a proportion p_i of heads in it has been obtained' $(i=1, 2, \ldots, n)$
and

S_C: 'On evidence $C_1, C_2, \ldots C_n$, the chance of heads in L is $\bar{p}_n$', where $\bar{p}_n$ is some average of $p_1, p_2 \ldots p_n$.

Mr Ellis asserts that S_T is an analytic statement of logical temperature on the strength of the analogy with S_C, which he must presumably take to be a statement of logical probability. But this is just false. In the first place, neither S_T nor S_C is analytic, and to suppose that they are is to forget yet again that quantities are cluster concepts and do not derive their meaning exclusively from one set of measuring operations. In the second place, S_C is not a statement of logical probability at all. The statement of logical probability that Mr Ellis is thinking of is

S_{PC}: 'On evidence $C_1, C_2, \ldots . C_n$, the probability of the hypothesis that the chance of heads in L is $\bar{p}_n$ is P_C.'

There is, of course, an exactly analogous statement of logical probability about the temperature statement S_T, namely,

S_{PT}: 'On evidence T_1, T_2, ... T_n, the probability of the hypothesis that the temperature of L is $\bar{t}_n$°C is P_T'.

It is quite clear that there is no statement of 'logical temperature' even remotely analogous to S_{PC} and S_{PT}. What Mr Ellis has done is to show that *chance* has a logic of measurement and estimation exactly analogous to that of temperature—a conclusion with which I entirely agree. But he has not thereby provided the connection of chance with logical probability which he rightly criticises Carnap for neglecting. The required connection has been provided by Ian Hacking in *Logic of Statistical Inference* (C.U.P., 1965) with the so-called Frequency Principle (not to be confused with the straight rule of induction). It would be nice to have a justification for this principle (I suspect that Braithwaite may have inadvertently supplied it in 'Why is it reasonable to base a betting rate upon an estimate of chance?' in *Proceedings of the 1964 International Congress for Logic, Methodology and Philosophy of Science*), but meanwhile it can be accepted as axiomatising a tacitly accepted connection.

These detailed criticisms of aspects of Mr Ellis's book are only made to throw its major, and pioneering, virtues into relief. It is a book well worth criticising. The central discussion of scales, of fundamental, associative and derived measurement is excellent, and one would like to hope that chapter 9 will put a stop to the flood of inane literature on units, dimensions and dimensional analysis. In all, a book to be read, critically and profitably, by all philosophers of science.

D. H. Mellor
Pembroke College,
Cambridge

Philosophic Foundations of Quantum Mechanics. By H. Reichenbach. Cambridge (paperback reprint), 1965. Pp. x+182. 12s. 6d.

Professor Reichenbach's book on the quantum theory which was first published in 1944 is now available as a paperback reprint. It (i) gives an introduction into part of the mathematics of the elementary quantum theory; (ii) discusses the familiar problems of interpretation; and (iii) suggests a new interpretation in terms of a three-valued logic. I shall comment on the last two items only.

(ii) is based on the distinction between *phenomena* ('which are determined in the same sense as the unobservable objects of classical physics') and *interphenomena* (which can be introduced 'only ... within the frame of the quantum mechanical laws'). It is assumed without further argument that the inferential chains leading to the interphenomena are 'of a much more