

I dissent completely, however, from his statements that "the criterion of this common-sense reality is universality of experience," and that "the mongoose was unreal because if the box were opened nobody would experience it." There is no such thing as a universal experience, and nobody would experience the mongoose, whether it was real or not. The only things we experience are sensations and certain processes, such as judgments and emotions, which we call mental. Each sensation or each judgment is absolutely private to one individual. Other people's sensations and judgments can be described to him, but he can appreciate them only through other sensations of hearing and seeing, and these are just as private as the first kind. Any satisfactory account of scientific method must therefore rest at bottom on the private sensation and the individual judgment. Other people provide me with additional data, but I make my decisions about them myself.

The common-sense criterion of reality, I contend, is that a large number of the sensations of the observer can be described in terms of a small number of assumed properties of the object by means of logically or mathematically simple laws. It is an experimental fact that this is possible with respect to many objects. In fact, the scientific notion of reality is securely based on experience, and cannot be altered by any argument or theory. Some realist philosophers would probably say that this criterion gives grounds for believing that something is "real" in a different sense from this; but, like Dr. Campbell, I find myself quite unable to understand what philosophers do mean by "real." To me the above criterion is the definition of reality. The fly on this sheet of paper (at the moment) is unreal because there are no sensations that can be concisely described in terms of it.

I question Mr. Hugh Elliot's assertion that "materialism happens to be true." I do not deny it, but I deny absolutely that Mr. Elliot knows it. Mental operations may be a function of material ones, but to find this out it would be necessary to show how all mental phenomena can be inferred from physical and chemical hypotheses, and this will never be known until psychology is a complete science. Materialism will be established, if at all, only at the very end of science. At present it is pure metaphysics.

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In his article in *NATURE* of October 20, p. 247, Prof. Wildon Carr has maintained that the relativity theory has made the reality of matter untenable. Later writers have denied this. May I state the relation of their views?

Einstein refers the universe to a system of axes fixed to an observer. The observer is a mind, and hence Prof. Carr regards the material axes as also of the nature of mind. The opponents of this view, accepting the axes as material, regard mind as derived from matter. The four axes of Einstein have no physical counterpart in matter. But the relativists have not envisaged any reality for the axes other than a material reality. Therein, it seems to me, lies the weakness of the relativist position.

The four-dimensional universe of Einstein is a hybrid made of mind (the observer) and matter (the axes). The material axes are the measuring rods of the observing mind. So long as we retain this hybrid character it is equally easy for opposing sides to claim mind or matter as the fundamental reality. The metaphysical definition of reality is that the ultimate is the real—that is, that the entity from which all other entities can be built up is the real. Science is not only concerned with the real of common sense, as Dr.

Norman Campbell seems to think, but is also concerned with the real of metaphysics. The former may be regarded as a horizontal section of reality and the latter as a vertical section—the breadth and depth of reality.

What the relativists have to show to substantiate the claim that mind is the ultimate reality is how to build matter from mind. The axes of reference, and not merely the origin, have to be of the mind-stuff. Then the universe would be perceived as a universe of mind-stuff. This is possible. A four-dimensional geometry of a universe of mind-stuff has yielded me a law of gravitation which is the analogue of Newton's first law of motion and automatically solves the problem of n bodies. The elaborate froth of the Einsteinian tensor analysis for obtaining the law of gravitation is due to the putting of the new wine of mind into the old bottles of material axes. In the four-dimensional universe of mind-stuff matter, space, and time find their place as growths from mind.

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Trinity College, Cambridge, December 9.

CANON McCURE's misconception is so fundamental that I ask leave to correct it. If he had done me the honour to read other of my writings, he would scarcely have suspected me of a desire to banish imagination from science. It is just because I maintain that the imaginative element gives to science its highest value that I think it important to distinguish carefully between what is fact and what is imagination. I do not "rule out, as scientifically invalid, Prof. Eddington's being travelling with the velocity of light"; but I say that the perceptions of that being are not facts, ascertainable by experiment; and I protest against any exposition of relativity, or of any other scientific doctrine, which confuses laws, based mainly on facts, with theories, based mainly upon imagination.

NORMAN R. CAMPBELL.

The Resonance Theory of Hearing.

Is it possible for the ear to distinguish two notes of the same pitch and of different quality sounding concurrently?

Evidently it is possible. Of a number of examples the following may be the simplest for experiment. Hum any note with the teeth touching, but not clenched. The performer may then hear the smooth hummed note and at the same time another rough note of the same pitch produced by the tapping of the lower teeth against the upper teeth. (Stop the ears.) Now imagine a tracing of the combined wave-form of any two notes of the same frequency to be submitted to the Fourier analysis. The result of the analysis must always be of the same nature; there is no alternative; "la solution est unique":—the complex sound giving the periodic curve will be shown to be made up of a series of pure tones of the harmonic scale with frequencies n , $2n$, $3n$, etc. If the ear acts as a kind of "practical Fourier's theorem" it can perceive only one fundamental tone. But we invariably judge of the pitch of a note by its fundamental tone. If, then, we hear at the same time two notes of pitch n , the ear must be able to perceive, also at the same time, two fundamental tones of frequency n —that is to say, it must be able to perform an analysis which is not in accordance with Fourier's theorem.

I mentioned this radical objection to the resonance theory of hearing in 1916 ("Questions of Phonetic Theory," p. 100), but nobody appears to have noticed it.

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