proposes ways to measure each of them which, he alleges, are on a par with physical measurement of length, mass, and the like. For loudness, select a number of faint tones that are deemed equally loud (presumably under some sort of standardized listening conditions). Without providing any evidence, Savage seems to believe that different observers with normal hearing will agree on these judgments. The loudness of any other tone is then the number of these "unit" tones which when played simultaneously are judged (approximately) as loud as the given one.

If my system of loudness measurement satisfies each of these axioms [those of extensive measurement], perhaps we can safely conclude that it does permit the application of arithmetical statements to loudness. It is noteworthy, then, that there do not seem to be any experimental facts indicating that all or even some of these axioms are not satisfied by the system proposed . . . [p. 239].

This last statement is bizarre. One consequence of the axioms is that any pair of unit tones must be just as loud as any other pair. Consider four unit tones which have the same frequency but of which the first pair is in phase and the second 180 degrees out of phase; the two sums are not equally loud. More generally, composite sounds created from unit tones of different frequencies may beat and not have a constant loudness. For pitch, Savage's scheme is an implicit form of difference measurement based on unit intervals rather than on unit objects. It rests on the ability of at least some people consistently to equate half-note differences. The issue of axioms adequate to permit the construction of a difference representation-such axiom systems existand whether they are empirically satisfied is hardly mentioned. Measurement entails difficult formal and experimental problems to which the author is little sensitive.

Given these schemes, Savage concludes that the resulting measures are physical. It seems odd to refer to an objective measure as "physical" when it plays no role in physical theory but is potentially important in psychology. Should we also say that "rate of money flow" is a physical rather than an economic measure?

The remainder of the book is a detailed critique of the psychophysics of G. T. Fechner (and incidentally of L. L. Thurstone) and of Stevens. Much of the criticism is exceedingly careful and useful. The ultimate conclusion is that, whatever is involved in their work, it is not measurement in the sense meant in the other sciences. What, then, are Stevens's methods getting at? Perhaps, as the name of one of them suggests, they yield estimates of some internal magnitude, of some physiological process. Even this is rejected, in part, by means of a splendid non sequitur:

... one way of emphasizing that [the observer] perceives no retinal, nerve, or brain processes is to point out that an observer who has never heard of retinas, optic nerves, or brains could function quite as well in [a magnitude estimation] experiment as a professional physiologist [p. 375].

Although he never comes right out with it, Savage evidently feels that Stevens's methods are without merit. Psychologists cannot help being sad to relinquish the innumerable neat formulations of regularities that are so easily uncovered in this way—and I rather doubt that they will relinquish them. One can agree that magnitude estimation and related methods do not constitute a form of fundamental measurement without, however, rejecting them as important sources of data.

The book concludes with the author's "radical view" of perceptual psychophysics, namely that it is "the science of perceptual abilities." Radical? Perhaps if you accept that "Psychophysics is traditionally defined as the science of relations between psychological dimensions . . . and physical dimensions" (p. 531), but most people called psychophysicists in fact study, and know they study, perceptual abilities-discriminability, sensitivity, and so on-and not so-called psychophysical laws. It should amuse these conservatives of psychology to be told that what they do is radical.

Because no other systematic and detailed philosophical critique of fundamental measurement in psychology exists, it is most unfortunate that this one is so deeply flawed. That which is good in it should not be lost because of its failures. It is at its best, although not most gracious, when it is critical; it fails utterly to convince when it attempts to be positive; and its ignorance of both elementary empirical facts and the modern measurement literature surely will not enhance the prestige of philosophical criticism among psychophysicists or measurement theorists.

R. DUNCAN LUCE Institute for Advanced Study, Princeton, New Jersey

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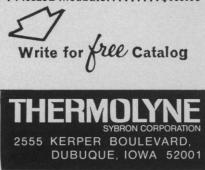
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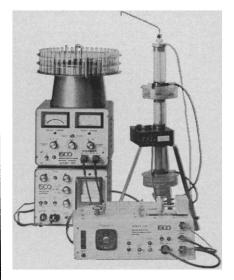
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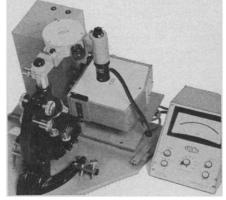
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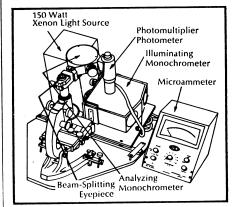
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