REVIEWS

J. Michell (1990). *An Introduction to the Logic of Psychological Measurement*. Hillsdale, NJ: Lawrence Erlbaum Associates, 190 pp.

For a long period, the literature on foundations of measurement contained some fine handbooks and edited volumes for the *connaissanceur*, but had no introductory textbook that could be taught at senior college or beginning graduate level. This situation has changed now that Joel Michell has published his introduction to the logic of psychological measurement. The author has done his best to make the book readable for a wider group of students than those interested in a career in measurement, and we should commend him for the result. Instead of long axiomatic treatments of abstract measurement theory, the book is full of lively descriptions of dramatic episodes in the history of psychological measurement, clear treatments of philosophical debates, careful attempts to explain underlying principles and axioms, and graphical illustrations of mathematical concepts. Moreover, the author knows how to write—his use of language is stimulating and just perfect for a book like this. In short, I wish this book had crossed my path when I was an undergraduate student. It would certainly have triggered my interest in measurement much earlier.

The book begins with a one-chapter section on the history of the concept of measurement. The next section contains three chapters on the theory of measurement in psychology, the concept of quantity, and the search of quantity in the absence of extensive measurement. Even though the title of this section promises philosophy, the author does not hesitate to throw in some further history of measurement or a few lucid treatments of mathematical concepts. In fact, the last chapter of the section is a didactic, yet extremely accurate introduction to additive conjoint measurement. The second half of the book is devoted to applications of the additive conjoint measurement model to Thurstone's model for paired comparisons, to procedures for multidimensional scaling and to Coombs' algorithm of unfolding. Each of these chapters first introduces the model or procedure and next shows how they are instances of additive conjoint measurement, and how additive conjoint measurement can be used to test the quantitative-ness of their scales. Also, each chapter contains a real-life data set that is used to demonstrate the calculations step by step. The last chapter deals with some remaining technical aspects and extensions. The book has an appendix that introduces the formal aspects of the concept of order—again in a very clear way, with a fine worked example, and without sacrificing any rigor.

In spite of the enjoyment in reading all other chapters, chapter 1 is my favorite, probably because there is so much I did not know before I read the book. Or did you already know that the one who introduced the quantitative structure of the variable length as the model of any quantitative variable was the 14th century French scholar Nicole Oresme? What the position was on quantitative measurement of such founding fathers of modern psychology as Fechner and Wundt. And that the one who most outspokenly linked the predicate science to quantitative knowledge and introduced the belief that all other claims on knowledge are obscure was Lord Kelvin? The cornerstones of the chapter are a description of Campbell's theory of measurement, with its important distinction between extensive and derived measurement, and the impact his

1920 monograph had on the community of psychologists in the 1930s and 1940s. It is shown how S. S. Stevens' definition of measurement scales weakened the dominance of Campbell's prerequisite of extensive measurement and brought relief to those poor psychologists who had to go without psychological concatenation operations, and who were now able to resort to lower levels of measurement on ordinal and nominal scales. A first definition of Stevens' scales—as well as a criticism of it—concludes the chapter.

The discussion on the theory of measurement in psychology is continued in chapter 2. The chapter has a complete section on Bridgman's operationalism, which is rejected as an unsound approach. The major part of the chapter contains a further description of Campbell's representationalism and Suppes and Zinnes well-known formalization of it, as well as a formalization of Stevens' definitions of measurement scales. Here, for the first time, the author shows his obsession with the basic doctrine of representationalism, which asserts that measurement is the mapping of empirical relational structures onto numerical structures. Rather than accepting that numbers are external to empirical facts, and that they are just convenient vehicles to represent these as measurements, he believes that numbers are empirical themselves, and that it is the researcher's task to discover them in the physical or psychological reality. We will get back to this position later on in the review.

Chapter 3 is a brief chapter that defines a quantitative variable as an ordered and additive structure. The chapter is more formal than the previous two, in that it presents systems of axioms of ordinality and additivity, but it provides the reader with enough intuition to appreciate the axioms. I wonder if the full axiomatization of the real-number system as a complete ordered field and the discussion of the Dedekind cuts will really please the kind of readers that should grab this book. Of course, they make the treatment complete, but a brief intuitive introduction would already have offered the reader sufficient ground to go on with the next—less formal—chapters. The main message in the concluding paragraph is, that a necessary condition of measurement, is to show empirically that the variable involved meets the axioms of quantitateness. The measurement process itself then is defined as “a procedure for identifying values of quantitative variables through their numerical relationships to other values” (p. 63). This definition again subtly demonstrates the author's belief of the existence of (real) numbers as empirical entities.

How variables can be shown to meet the assumptions of an ordered and additive structure is the main topic of chapter 4. In Campbell's approach it is considered to be necessary to find an empirical operator—the well-known “concatenation” operator—that defines the empirical relational system to be mapped onto the numerical system. Psychology has never been able to find concatenation operators for its key variables. The author's response to the problem is Luce and Tukey's (1964), who proposed the theory of conjoint measurement to put quantification in psychology on a sound footing. Chapter 4 offers the best introduction to additive conjoint measurement psychology students may wish to use. All axioms and steps are carefully explained. For example, the condition of double cancellation, which students invariably find hard to understand when being introduced to it for the first time, has many instructive graphical illustrations. A section on the applicability of conjoint measurement to physical concatenation operations and to the measurement of velocity will give the student a feel for its generality.

Chapters 5 through 8 are reviewed in combination. Each chapter introduces a well-known measurement model or procedure. I would not mind giving these chapters to students as a brief introduction to Thurstone's model for paired comparisons data (chapter 5), multidimensional scaling (chapter 6), or Coombs' unfolding (chapter 7). Each introduction is self-contained, has a multitude of graphical illustrations, and uses

a motivating empirical data set to exemplify the calculations. The goal of each chapter is to demonstrate that the model or procedure defines variables that meet the conditions of additive conjoint measurement. Therefore, testing the conditions provides a way of verifying that the variable is quantitative. It should be realized that these conditions are necessary but not sufficient for the underlying model to hold. Also, for the Thurstone model the fact that additive conjoint measurement is based on a deterministic model creates problems. The conditions of additive conjoint measurement constrain the response probabilities, and it is not correct, as the author proposes, to use a series of statistical tests on probabilities in adjacent cells, because that would ignore the dependence between their results. In fact, the whole idea of testing a stochastic model by imposing a deterministic model on the data is not sound; much better tests for the goodness of fit of Thurstone's model are available. The procedures for multidimensional scaling and unfolding in the other two chapters are deterministic by their nature, and the application of additive conjoint measurement to demonstrate the quantitative-ness of their variables and dimensions is much better appreciated.

As already noted, the last chapter in the book deals with some remaining technicalities. It also discusses the application of additive conjoint measurement to factor analysis of test items to demonstrate Spearman's general ability factor. The first section of the chapter makes a case for more rigorous stimulus control in psychological measurement. Unless psychologists will provide more narrowly worded sets of statements and problems, differing only on a single dimension, psychology will never find variables that are quantitative, believes the author. By and large I agree, but I add that such recent developments as multidimensional models in item response theory could be used to do the job if sloppiness in item formulation still prevails. The last pages of the chapter present a more mathematical treatment of measurement theory. The mathematical level of these pages is much too high for students for which the book apparently has been designed. Reserving this topic for a second appendix might have been a better choice.

The above shows how much I have appreciated the book as a textbook for an introductory course on the foundations of measurement in the behavioral and social sciences. This fact does not imply that I fully endorse the author's opinion or his selection of subjects. One problem is the author's view of numbers as empirical facts rather than abstract entities and his continuous criticism of the representational view of measurement. I do not think these opinions are productive. The idea that mathematics is an empirical science has been abandoned for a long time. Apparently, the author finds it difficult to separate language from reality. If I give an eyewitness account of an event, can it be true only if words exist in reality? How about arbitrariness of scale? If numbers exist the way the author believes they do, they must be absolute. The point is not the existence of *numbers*, but the fact that they are convenient vehicles to reveal isomorphism of *structure*.

A more serious problem, however, is the fact that the author does not seem to be aware of stochastic models for the measurement of abilities and attitudes that have abounded the literature since the 1950s, and which now dominate most applications. These models, if they work statistically and fit the data, produce quantitative variables, and there is no need to test them against the conditions of additive conjoint measurement. For an important class of models we even have extensive literature on their foundation as a measurement model (Rasch, 1961). Michell's book contains no reference to those developments whatsoever. The way he deals with Thurstone's model in chapter 5 does not show much respect for its stochastic nature at all. No doubt this is typical of the whole tradition of mathematical psychology, the main field where the interest in foundations of measurement has been kept alive. After many years the reviewer attended a recent meeting of the European Mathematical Psychology Group

and was shocked to still find mathematical psychologists presenting work that basically focused on Guttman's scalogram analysis and psychometricians dealing with statistical aspects of extensions of item response models at the same conference without referring to each other's work. Both traditions could learn from each other.

The final point is related to the previous one. Throughout the book, the model of additive conjoint measurement is the author's only point of reference. Although the author does not state this explicitly, he seems to assume that, unless a model falls within the scope of additive conjoint measurement, no quantitative measurement is possible. A slightly more general orientation would have made the book much stronger. The basic message to be derived from Luce and Tukey (1964) is *not* that their additive model is necessary for quantitative measurement. As these authors demonstrate, if we are unable to find a concatenation operator to demonstrate the quantitative nature of a single variable, we may proceed by modeling several variables *jointly*, finding numbers that fit the model to the data. In doing so, it is the structure of the model that determines the scale of the variable. And it is this message that has paved the way for us to appreciate modern psychometric models as true measurement models.

AMERICAN COLLEGE TESTING PROGRAM

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References

- Campbell, N. R. (1920). *Physics, the elements*. Cambridge: Cambridge University Press.
- Luce, R. D. & Tukey, J. W. (1964). Simultaneous conjoint measurement: A new type of fundamental measurement. *Journal of Mathematical Psychology*, 1, 1-27.
- Rasch, G. (1961). On general laws and the meaning of measurement in psychology. In J. Neyman (Ed.), *Proceedings of the Fourth Berkeley Symposium on Mathematical Statistics and Probability*. Berkeley, CA: University of California Press.