Measurement and the Oral Biologist

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"The trouble with the idea of measurement is its seeming clarity, its obviousness, its implicit claim to finality in any investigative discourse."[5] Measurement in reality stands at a critical point between the theory and a type of experience commonly named as sensory, immediate or datal. Irrespective of which field of research is under review, be it dentally orientated or otherwise, there is one term in constant use which embodies all that the latter type of experience characterises, namely, *observation*. Naturally, this particular word succeeds in obscuring and distorting a great variety of problems and its coverage of meaning often overlaps that of measurement. In a highly skilled and technical discipline such as dentistry, a detailed description of the instruments being used and the recording of a number appears to be the basis upon which many researchers recognize the term *measurement*. After a little thought, however, it is clear that it is rapidly becoming a function of "look and see." The present writer cannot claim to be able to divorce himself completely from this phenomenon, nor does he assume a full understanding of the philosophical and practical problems that lie beneath, for that would need a lifetime, not to mention a little diligence. The importance lies in being aware that there is another side of the tale and that even a little knowledge of it immediately increases the breadth of spectrum and allows a certain degree of insight to temper the application and the meaning derived.

The difference between quantitative and nonquantitative information or results always seems to imply that it is a simple contrast between the "precise" and the "vague" information. Accuracy or precision is undoubtedly useful, as long as the aim is not to obtain it for its own sake. A mandible or a tooth, for example, can be measured accurately and the results can be used to make fine distinctions of the amount of growth comparable with other mandibles or teeth. It can therefore be said that the measurement of length satisfies the requirement and that we need look no further except to remember that there are boundaries beyond which there remain problems of length measurement still unsolved—the very far and the very fine.

Measurement can be defined in direct terms of its function: "It is a way of obtaining symbols to represent the properties of objects, events, or states, which symbols have the same relevant relationship to each other as do things which are represented."[1] Thus measurements let us compare the same properties of different things, the same property of the same thing at different times, and let us describe how the properties of the same or different things are related to each other. The word arithmetisation is commonly used for any procedure of allotting numbers to objects, events or properties. Generally, measurement is restricted to processes which involve the use of a constant unit. In the scientific field it has generally become more common to apply the term "measurement" to any process which involves "the assignment of numerals to objects or events according to the rules"[6,7] or "the assignment of numerals to represent properties."[2,3,4] In the light of this the purpose of measurement can be said to represent the content of observations by symbols which

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are related to each other in the same way that the observed objects, events or properties can be.

For those who may wish to delve further, a classification of scales of measurement was suggested by Stevens[6] and was based on the premise that measurement is the assignment of numerals to events or objects according to a rule. He formulated four kinds of scale: nominal, ordinal, interval or ratio. The numbering of classes of objects or events yields a nominal scale; the result of a ranking procedure is an ordinal scale, while measurement in a more restricted sense produces either an interval or a ratio scale.

All types of measurement are subject to errors and a simple count, classification, interval or ratio scale is not meaningful without some idea as to its accuracy. The amount of error present can only be estimated when one knows whether the results are usable in a pure or applied situation. Measuremental errors can stem from a number of sources which may act singly or in combination. The accepted main sources of error can be classified as follows:

1. Observer error,
2. Instrument error,
3. Environmental error, and
4. Object error

Let us take these in turn, although they may appear familiar, and find out what each covers.

Observer Error

This is naturally self-explanatory in that the observer is either not being careful or (to give the benefit of the doubt) it is not possible to do so. Under such conditions the observed results are usually open to bias.

Instrument Error

This is a much more common occurrence than is usually realized and, for a simple demonstration of this, one has only to turn to the ordinary twelve-inch ruler to find a wide range of inaccuracies. Many instruments can be inconsistent or variable and, like weighing balances, spring calipers, etc., must be corrected. When results involve both observer and instrument, they can be considered as a combination which will produce a summation of error. Constant checking and maintenance are the only ways of controlling instrument errors which will also be much greater if the particular instrument is used by the many. Theoretically the answer to the problem is the best possible combination of observer and instrument.

Environmental Error

Conditions under which research is undertaken are often prone to extensive variations which will have a direct effect on the observer, the instruments, or the object in view. Temperature is an example which springs to mind and anyone who has attempted to obtain sections from a softening wax-embedded specimen while other members open doors or windows to "let in the cool air," accompanied with a dispersion of sections, needs no further introduction.[1] The standardizing of conditions must be the main aim even if only partly achieved.

Object Error

This is more difficult to define but it can be outlined in noting that the act of observation may affect the behavior of the observed so that natural behavior is not forthcoming—supervisor breathing down the neck of a research student. This type of error is found particularly during animal behavior studies and is considerably reduced by the use of laboratory animals although the movement, switching on of lights, etc., might well disturb the behavioral pattern.

A large part of dentistry, both clinical and research, falls within the general biological field, and measurement of teeth, bone and soft tissue is, at best, subjective when compared with the whole. In other words, one may be accurate in measuring the length of a particular mandible, but on attempting to measure another mandible the actual points by which the measurement is made are based on a subjective assessment or selection and this in turn makes the actual figures open to error. On the other hand, if we are examining an aspect of biological growth, the figures obtained by our measuring procedures should be accurate enough to enable growth to be observed as a dynamic trend. The trap into which the unwary fall is the use of figures taken to several decimal places which in itself gives an air of accuracy. In some instances such figures are acceptable but in many others their inclusion only subserves inaccuracy since the magnitude of the errors is greater. Measurements should be judged by the method applied, the type of material being measured, and the aim of the exercise. Since biological growth is a dynamic process, a measurement of the tissues at any particular moment in time can never be complete. After the waxing of growth there follows the waning so that, although the changes of development are more dramatic, the changes of aging and decline constitute an active process. Measurement, therefore, is a kind of "static" description which provides a sequence of separate aspects suited to the representation of pattern but not to the representation of growth. Thus measurements of biological material are, in fact, indicators of sufficient accuracy to allow the ebb and flow of changes to be recorded. The one truly measureable part of the body which, after development, does not undergo the intrinsic changes associated with the soft tissues and bone is the tooth. The measurement of a mature tooth depends upon the observer and the instruments which, apart from errors, are the nearest to true mathematical interpretation.

Finally, in the light of the above discussion, it is necessary to emphasize that measurements, although obtained as accurately as possible, are fundamentally subjective because of the procedure needed to obtain them and, although usually adequate for the purpose, one must guard against the implication of true mathematical precision which figures usually tend to convey. For the biometrically orientated oral biologist one proviso must remain paramount—mathematics imply finalization . . . one cannot finalize biological phenomena!

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