Notes and Comment

Absolute and other scales: Question of validity

J. J. ZWISLOCKI

Syracuse University, Syracuse, New York

In an article entitled "Evidence against 'absolute' scaling," Mellers (1983) describes an experimental result she regards as proof that the absolute scaling advocated by Zwislocki and Goodman (1980) is no more absolute than ratio scaling by magnitude estimation or category scaling. The result concerns similar biases produced in all three scales by manipulation of a stimulus context. She presented 11 25-mm squares containing various numbers of irregularly distributed black dots and asked her subjects to scale the apparent darkness of the squares. The latter were shown simultaneously in one of two patterns of darkness distribution. In one pattern, the stimuli were bunched at the low end of their range, and in the other, at the high end. Since instructions considered by Mellers as identical to those of Zwislocki and Goodman failed to reduce the biases associated with the skewed stimulus distributions, they do not lead to an absolute scale, she concludes.

It appears to me that Meller's experiment is based on a fundamental misunderstanding of the concept of absolute scale accepted by Zwislocki and Goodman, which is derived from Stevens's (e.g., 1951) classification of scales and is much less ambitious than Mellers's. Stevens's classification is mathematically formal and based on permissible transformations under which the scales remain invariant. The highest level scale he considers is the ratio scale, which allows only one transformation—multiplication by a constant. In his first fundamental article on magnitude estimation, Stevens (1956) describes biases resulting from such a transformation, however, and shows that the scale biased the least according to his criteria is obtained when the experimental subjects (observers) are allowed to choose their own reference standards or moduli. This amounts to choosing their own units. As shown on several occasions (e.g., Hellman & Zwislocki, 1961; Zwislocki & Goodman, 1980), the choice is not arbitrary. If units of measurement cannot be designated arbitrarily by the experimenter, so that even a multiplicative transformation is excluded, the scale must become formally absolute.

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We did not make a secret of accepting this concept and stated in the first paragraph of our article (Zwislocki & Goodman, 1980): "To be sure, a ratio scale allows multiplication by a constant (e.g., Stevens, 1951), whereas the absolute scale implies a fixed unit."

A fundamental difference exists between a formally defined scale and its experimental realization. There is no *a priori* reason to assume that a scale formally defined as absolute should be less prone to experimental biases than some other scales. On the contrary, theory and past experience indicate that it is vulnerable to one more class of bias than a ratio scale. The latter must be independent of the units of measurement and, therefore, of the reference modulus imposed by the experimenter. On the other hand, an absolute scale is expected to be biased if an inappropriate modulus conflicting with a subject's natural unit is imposed. This has been confirmed experimentally (Hellman & Zwislocki, 1961). By extrapolation, an interval scale said to be realizable with the help of category scaling should be immune to one more class of bias than the ratio scale since it allows the addition of a constant.

Bias in psychophysical experiments means that subjects do not follow accurately the experimenter's instructions. For example, when the form of a scale changes as the reference modulus is changed, we have to conclude that the subjects involved do not obey ratio-scaling instructions. However, it is possible to arrange the experimental conditions so that they do. This is evident in Figures 2 and 3 of Zwislocki and Goodman (1980) for small ratios between the assigned numbers and the designated moduli. Clearly, the observation that subjects do not respond according to one or another scale definition under one set of experimental conditions does not mean that they cannot do it under a different set.

It is up to the experimenter to arrange the conditions so that his or her subjects are enabled to follow the imposed rules. To demonstrate the realizability of a scale, it is sufficient to find one set of conditions under which the scale can be proved to exist. The discovery of circumstances that preclude the achievement of a scale does not constitute a proof of its general lack of validity. Such a discovery must be possible for any type of scale. Even in physics, measurement requires rigorously defined conditions. Gravitational acceleration is the same for all objects at any one point of the earth, but this can only be observed in vacuum. In air, objects of smaller density fall more slowly than those of greater density. Does this effect of air (context) mean that the gravitational

constant measured in vacuum is incorrect or, perhaps, that it does not exist?

Zwislocki and Goodman have specified a set of conditions under which absolute psychophysical scales can be demonstrated; so have other investigators mentioned by them, especially Hellman and Zwislocki (1961). This is obviously not true for Mellers's experiment. Since she found strong biases with the types of instructions that, under favorable circumstances, lead to absolute, ratio, and interval scales, respectively, none of these scales were achieved. The highest level of invariance that can be discerned in her results does not exceed the level of rank order. According to Stevens's (1951) classification of scales, this corresponds to an ordinal scale which allows any monotone transformation.

What are the possible reasons for the failure of Mellers's subjects to produce an absolute scale? To begin with, her instructions were not identical to those of Zwislocki and Goodman—she missed an important point. Referring directly to the stimulus context, Zwislocki and Goodman had stated: "do not worry about numbers you assigned to preceding lines." Mellers could not have included this statement, not only because she did not use lines, but also because all her stimuli were presented simultaneously.

The simultaneous availability of all the stimuli to her subjects may have constituted the main reason for the strong biases Mellers found. Quite in agreement with Parducci's (1974) theory, she mentions, the ever present context exerted a strong influence on their responses. The other scales, ratio and cate-

gory, attempted by Mellers seem to have fallen into the same pit, whose attraction may have been potentiated by the difficulty of the subjects' task. They were requested to respond to darkness, but the dot patterns used to produce it hardly evoke the impression of darkness variation over much of the stimulus range—the dots are too few and too far apart. Perhaps it would have been easier to scale their numerosity.

Altogether, Mellers's experiment appears to me as convincing as weighing a small quantity of liquid in a large container of unknown weight.

REFERENCES

- HELLMAN, R. P., & ZWISLOCKI, J. Some factors affecting the estimation of loudness. *Journal of the Acoustical Society of America*, 1961, **33**, 687-694.
- MELLERS, B. A. Evidence against "absolute" scaling. *Perception & Psychophysics*, 1983, **33**, 523-526.
- PARDUCCI, A. Contextual effects: A range-frequency analysis. In E. C. Carterette & M. P. Friedman (Eds.), *Handbook of perception* (Vol. 2). New York: Academic Press, 1974.
- STEVENS, S. S. Measurement and psychophysics. In S. S. Stevens (Ed.), *Handbook of experimental psychology*. New York: Wiley, 1951.
- STEVENS, S. S. The direct estimation of sensory magnitudes—Loudness. *American Journal of Psychology*, 1956, **69**, 1-25.
- ZWISLOCKI, J. J., & GOODMAN, D. A. Absolute scaling of sensory magnitudes: A validation. *Perception & Psychophysics*, 1980, **28**, 28-38.

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