A critique of Dawson and Miller's "Inverse attribute functions and the proposed modifications of the power law"

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Dawson and Miller (1978) interpret the results of a set of experiments to support a modification of S. S. Stevens' power equation for loudness, and in particular to argue for a particular interpretation of this modified equation. A simple power function takes the form $y = ax^b$; $\log y$ plots against $\log x$ as a straight line with slope b . In a nutshell, when Dawson and Miller used the method of magnitude estimation to scale loudness and its inverse softness as functions of sound pressure, log-log plots of the results were not straight lines, but displayed notable curvature. Both the functions for loudness and the functions for softness bend at the low-number ends of the scales. Both sets of functions, Dawson and Miller found, could be described by equations of the form $y = ax^b - c$; b is a positive number for loudness, a negative number for softness. They interpret this finding to mean that subjects misset their "zero" point when they make their judgments—that the additive constant, c , represents a numerical bias; that subjects, in effect, subtract a certain number of units (c) from loudnesses and softnesses.

In my opinion, this "zero-bias" interpretation is implausible. The reasons for this opinion are simple, and can be gleaned from Figure 1, which graphs (1) simple power functions for loudness and for softness (straight lines); and (2) power functions for loudness and for softness modified by subtracting a constant (curved lines). The curves represent examples of Dawson and Miller's equations. Although the equations serve adequately to describe the data that are reported, difficulties arise when we consider what the equations predict about the subjects' judgments of softness at sound pressure levels higher and lower than those that Dawson and Miller employed.

Judgments at high SPL. By modifying the softness equation with a subtractive constant, Dawson and Miller predict the judgment of softness to go to zero at some high, but finite, SPL (and, if taken literally, to become negative at still higher levels). This reader finds it hard to believe that subjects will assign "zero" to the softness of some high-SPL sound. At any rate, the prediction is readily testable, but has not been tested.

Given so unlikely an outcome, the relevant experiment needs to be conducted before credence is given to the proposed equation.

Figure 1. Log-log plots of psychophysical functions for loudness and softness. The straight lines are simple power functions; the curved lines, power functions modified by subtracting a constant. The parameters of the curves (e.g., the slopes of the lines, the "thresholds" for loudness and softness) are meant only to be illustrative.

Judgments at low SPL. The modified equation for softness says that the judgment of softness will increase continuously as the sound pressure level decreases, the judgment approaching an infinite value at a stimulus level of zero. Two problems arise from this prediction.

First, it is not at all clear that subjects comprehend, explicitly or implicitly, the correspondence between infinite softness and zero loudness. To the best of my knowledge, this correspondence has never been tested empirically. Yet it is a simple matter to include in the stimulus set an inaudible (or zero) stimulus level—or even just to ask the subjects what number they would assign to a level that was not heard. Studying the input-output behavior of a human subject in a psychophysical scaling task is much like studying the analogous behavior of many physical devices: The gas gauge in my car purportedly indicates the volume (gallons) of gasoline in the tank. When the gauge shows "zero," the tank is supposedly empty. Given some external standard measure, I can "calibrate" the gauge, which may or may not give a reading proportional to the volume of the tank's contents. Similarly, if a device were produced to display the inverse (reciprocal) of volume, it should indicate an infinite value when the volume is zero (tank is empty). Perhaps an even better example would be a device that purported to read electrical resistance (ohms) and its reciprocal, conductance (mhos). Psychophysics asks analogous questions about judgments of "sensation."

The second difficulty is that the equation for softness makes no provision for the fact that the detect-

ability of the sound stimulus becomes probabilistic at very low intensities. It is not at all clear that, as SPL decreases, the power function will continue upward indefinitely, that is, that softness will continue upward into regions where the sound is not even heard on greater and greater proportions of trials. Indeed, it isn't clear how to define the average softness of sounds that are not always heard. The problem here centers on Dawson and Miller's equations being essentially "thresholdless." The model underlying their equations assumes that processes underlying sensory responses to near-threshold levels and below-threshold levels do not differ from processes underlying responses to higher levels. Curvature in the psychophysical functions is assumed to derive wholly from bias in number behavior.

Summary. The behavior of the subjects in judging loudness and especially softness at very high and very low SPL is still not well understood. The curvature that is clearly evident in the data presented by Dawson

and Miller requires some sort of modification of the simple power equation (or possibly some other sort of equation). Modification of the power functions by means of additive constants yields predictions that, to this reader, appear implausible. But they are readily testable predictions. If tests fail to support modification by additive constants, some other formulation will be needed. It may well be that some kind of numerical response bias is responsible for at least part of the curvature evident in the functions, but mathematics provides many ways to describe curves.

REFERENCE

DAWSON, W. E., & MILLER, M. E. Inverse attribute functions and the proposed modifications of the power law. *Perception & Psychophysics*, 1978, 24, 457-465.

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