

# Continuing Commentary

*Commentary on Gregory R. Lockhead (1992) Psychophysical scaling: Judgments of attributes or objects? BBS 15:543–601.*

**Abstract of the original article:** Psychophysical scaling models of the form  $R = f(I)$ , with  $R$  the response and  $I$  some intensity of an attribute, all assume that people judge the amounts of an attribute. With simple biases excepted, most also assume that judgments are independent of space, time, and features of the situation other than the one being judged. Many data support these ideas: Magnitude estimations of brightness ( $R$ ) increase with luminance ( $I$ ). Nevertheless, I argue that the general model is wrong. The stabilized retinal image literature shows that nothing is seen if light does not change over time. The classification literature shows that dimensions often combine to produce emergent properties that cannot be described by the elements in the stimulus. These and other effects cannot be adjusted for by simply adding variables to the general model because some factors do not combine linearly. The proposed alternative is that people initially judge the entire stimulus – the object in terms of its environment. This agrees with the constancy literature that shows that objects and their attributes are identified through their relations to other aspects of the scene. That the environment determines judgments is masked in scaling studies where the standard procedure is to hold context constant. In a typical brightness study (where different lights are presented on the same background on different trials) the essential stimulus might be the intensity of the light or a difference between the light and the background. The two are perfectly confounded. This issue is examined in the case of audition. Judgments of the loudness of a tone depend on how much that tone differs from the previous tone in both pitch and loudness. To judge loudness (and other attributes) people first seem to process the stimulus object in terms of differences between it and other aspects in the situation; only then do they assess the feature of interest. Psychophysical judgments will therefore be better interpreted by theories of attention that are based in biology or psychology than those (following Fechner) that are based in classical physics.

## Processing attributes and judging objects

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**Abstract:** Given that psychophysical responses are not a function of a single property but vary with a variety of stimulus and context variables, Lockhead has little hope for laws relating behavior to the environment. However, progress can be made with tasks that manipulate multiple sources of information to test formal information-processing models.

Unidimensional psychophysical models are scrutinized and criticized by Lockhead (1992). He argues that psychophysical responses are not a function of a single property but vary with stimulus and context variables. Perceptual judgments also change dramatically as the stimulus environment changes. Given these observations, Lockhead paints a pessimistic picture of one of the central building blocks of psychological science, relating behavior to the environment. One of the primary justifications for this solipsism is that perception is putatively holistic rather than an outcome that emerges from processing the elements in the stimulus. As he argues forcibly, unidimensional psychophysics is doomed because perceivers cannot judge one absolute stimulus property independently of other stimulus properties, the context containing the stimulus and the presentation of earlier stimulus events. I agree with the results described by Lockhead, but not with his assessment of their implications for psychological inquiry and theory.

The primary limitation of traditional psychophysics and Lockhead's alternative is that they are grounded in traditional stimulus-response (S-R) psychology. The goal of the S-R paradigm is to predict behavior simply on the basis of the stimulus. Missing from Lockhead's target article is the information processing approach in which behavior is understood as emerging from a sequence of processing events or stages (Massaro, 1989a). The major indication that Lockhead's is an archaic approach is

his apparent equation of the terms "judgment" and "perception." In this commentary, I show how the information-processing approach can illuminate traditional psychophysics, Lockhead's criticisms, and his suggested alternative. To succeed in this critique, we must be concerned with intervening stages of processing, acknowledging that perceivers are influenced by multiple sources of information, and we must provide models that describe the time course of information processing.

The goal of traditional psychophysical scaling has been to define a model relating some attribute of the stimulus to some response,  $R = f(A)$ . As attested to by the controversy in this field (Krueger 1989), this goal has not been reached. Signal detection theory, on the other hand, acknowledged that such a simple function was not possible. To provide an adequate description of performance, it is necessary to separate sensory and decision factors in the psychophysical task. Response probability is determined by both of these processes; it is not possible to predict the response given a model of just the sensory process. It is fair to say that accounting for both sensory and decision factors has advanced our understanding of performance in basic psychophysical tasks (Macmillan & Creelman 1991; Massaro 1989a, Chs. 10–12). A similar advance in psychophysical scaling will also require dissecting the stages of processing intervening between stimulus and response.

Lockhead's observation that subjects are not capable of judging one attribute independently of others was anticipated by other scientists not cited in his target article. Egon Brunswik is the most notable absentee. Brunswik, more than anyone else, deserves recognition for the early acknowledgment of the multiple but ambiguous sources of influence on behavior. He stressed "the limited ecological validity or trustworthiness of cues . . . To improve its (the organism's) bet, it must accumulate and combine cues" (1955, p. 207). Consider an early experiment of Brunswik (1934). Subjects were asked to equate two groups of stamps that varied in number, size, and monetary value. When subjects were instructed to use just one of these three dimensions, their judgments were nonetheless significantly influ-

enced by the irrelevant dimensions. Told to equate two groups of stamps with respect to number, subjects were influenced by the size and value of the stamps. Integrating multiple sources of information appears to be a natural function of human endeavor. Influences from multiple sources appear to occur to some extent regardless of the goals and motivations of the perceiver (Massaro 1987, pp. 66–73; 1989b).

Although psychophysical judgments are influenced by multiple sources of information, the theoretical explanation of this influence remains an open question. Lockhead's interpretation falls back on the idea of holistic perception, a thesis entrenched in psychological history (James 1890; Werner 1957). As I have pointed out elsewhere, however, (Massaro 1987) holistic processing is not theoretically meaningful. Somehow we perceive the whole, but not by way of its components. Lockhead argues for holistic perception of integral stimuli whose components cannot be processed independently. (Lockhead is somewhat inconsistent in this regard, because his Equation 5, which he uses to describe performance, breaks the whole into component influences.)

Our differences are best illustrated in the case of explaining judgments in complex situations. Lockhead uses the Ames distorting room or its variants to demonstrate a perceiver's inability to perceive some attribute independently of context. The contextual situation influences the perceived size of a woman in the scene. We find it difficult to report a single attribute independently of other attributes and independently of context. As stated by Marcel (1983), we experience events at more global levels. However, this experience does not mean that the underlying processing was holistic. It remains possible that the processing that led to the experience was on the elements making up the display. In visual perception as in other domains, there are multiple sources of information (Bruno & Cutting 1988; Massaro 1988; Massaro & Cohen 1993). Subjects simply evaluate and integrate these multiple sources to achieve perceptual recognition.

Lockhead distinguishes between separable and integral stimuli. From his perspective, manufactured objects tend to be separable stimuli. Natural objects, on the other hand, tend to be integral in that "judging one attribute depends intimately on some other attribute" (1992, p. 556). There is very little evidence for truly integral stimuli, however, except perhaps for color (Massaro 1987, Ch. 8; Thompson & Massaro 1989). In fact, there is good evidence that the dimensions of typical stimuli can be processed independently of one another at early stages of perceptual processing. Consider an experiment carried out by Moore and Massaro (1973): Subjects were asked to identify both the loudness and the quality of a test tone. The pattern of concurrent responses indicated that the two dimensions were processed independently of one another. According to Lockhead (also Garner 1970), these two dimensions should be integral and should not be capable of being treated independently of one another. Thus, we see that an accuracy measure reveals independence whereas a scaling measure might not. This difference illustrates that we cannot take the psychophysical judgment of the subject as directly mirroring the perceptual processing that led up to that judgment.

Lockhead erroneously equates a subjective report with the processing that led up to that report. This misjudgment is reminiscent of previous interpretations of categorical speech perception (Massaro 1987, Chs. 4 and 5). Although subjects report categorically, the speech processing and its outcome could be continuous. Although the report of loudness is influenced by several sources of information, the processing of intensity could occur independently of other properties of the stimulus and independently of situational context. These other properties might have their influence at later stages of processing.

To be scientifically viable, Lockhead's research program must be modified along two significant dimensions. Methodologi-

cally, the psychophysical task has to be extended to manipulate multiple attributes or sources of information. This extension has already illuminated fundamental properties of pattern recognition, memory, and decision making (Massaro 1992). Theoretically, competing theories must be formalized as information-processing models (Massaro 1989a; Massaro & Cowan 1993). Until these modifications are instantiated, Lockhead's critique of traditional psychophysics does not move beyond an inflexible S-R psychology. Any significant advance in theory and experimentation must be informed by the last decades of the information processing approach. The latter approach makes possible the systematic study of the influence of multiple sources of information, the isolation of intervening processes, and tracking the dynamics of information processing (Massaro & Cohen 1991).

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### Arguments in favour of a psychophysical

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**Abstract:** In contrast to Lockhead's view it is argued that psychology as a genuine science must not be based on other sciences and that psychological measurements have to be validated inside psychology. It is pointed out that psychological scalings, unaffected by judgment contexts, can be obtained if the experimental setting is compatible with everyday situations.

The questions asked by Lockhead (1992) are important because his answers negate the possibility of quantitative measurement in psychology. I should like to argue that it is worth pursuing the concept of quantitative psychology and that it is a mistake to base psychology on physics.

**The true function.** Imagine two physicists, each measuring a dimension of, for example, cubes of different sizes – one measuring the length of the sides and the other the weight. When they plot both results in one graph, they find a nonlinear relation between the measurements and are probably happy to have discovered a regularity.

Lockhead reports how the story might end if two psychophysicists did the same. Then, we assume, each would declare his findings a general law and refute those of his colleague. Thus Stevens's (1961) "and to repeal his law" article began a continuing controversy over the true function. The development reported by Lockhead can be supplemented by another democratic solution. Mittenecker (1975) writes that Stevens is right because his law is accepted by the majority of scientists.

The fact that Stevens's findings were different from Fechner's should concern us only if both functions were based on the same measurement procedure. This is not the case. In magnitude estimation the subject's task is completely different from what Fechner's methods probe. This becomes obvious when Stevens (1957; 1975) interprets his results as if the subjects had estimated stimulus ratios.

Different procedures describe different aspects or dimensions of the stimuli to be judged. The procedure influences and defines the phenomenon to be judged. This is what Witte (1958) calls the dependence of the phenomenon on the method and (vice versa) the dependence of the method on the phenomenon.

Using the same set of stimuli, Heller (1980) showed that both