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Characterizing Human Perceptual Inefficiencies with Equivalent Internal Noise

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A widely used method for characterizing and comparing inefficiencies in perceptual processes is the method of equivalent internal noise -- the amount of random internal noise necessary to produce the degree of inefficiency exhibited by the perceptual system in processing [J. Opt. Soc. Am., 46, 634 (1956)]. The amount of equivalent internal noise is normally estimated by systematically increasing the amount of external noise added to the signal stimulus and observing how threshold -- signal stimulus energy required for an observer to maintain a given performance level -- depends on the amount of external noise. In a variety of perceptual tasks, a simple noisy linear amplifier model [D. Pelli, Ph.D. dissertation, University of Cambridge, Cambridge, UK, 1981] has been utilized to estimate the equivalent internal noise Ninternal by fitting the relation between threshold contrast and external noise Next at a single (d´) performance level : .This model makes a strong prediction: Independent of observer and external noise contrast, the ratio between two thresholds at each external noise level is equal to the ratio of the two corresponding d´'s. This potential test for the internal consistency of the model had never been examined previously. Here, we estimated threshold ratios between multiple performance levels at various external noise contrasts in two different experiments: Gabor orientation identification and Gabor detection. We found that, in both identification and detection, the observed threshold ratios between different performance levels departed substantially from the d' ratio predicted by the simple noisy linear amplifier model. An elaborated Perceptual Template Model (PTM) [Vis. Res., 38, 1183 (1998)] with nonlinear transducer functions and multiplicative noise in addition to the additive noise in the simple liner amplifier model leads to a substantially better description of the data, and suggests a reinterpretation of earlier results relying on the simple noisy linear amplifier model. The relationship of our model and method to other recent parallel and independent developments [J. Opt. Soc. Am. A, 14, 2406 (1997)] is discussed.