Model of visual contrast gain control and pattern *and noise* masking

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Abstract. If detection were governed by an isolated (and possibly nonlinear) transducer, then a linearization of the psychometric function (d-prime vs. target amplitude) must accompany any threshold elevation due to the addition of external noise. This is the Birdsall theorem (Lasley & Cohn, 1981, *Vis. Res.* 21:273). From the fact that full-field, white, dynamic visual noise elevates threshold *without* linearizing the psychometric function (Baker & Meese, 2012, *J. Vis.* 12:10:20; Solomon & Tyler, 2017, *J. Opt. Soc. Am. A* 34:870), we can safely infer that detection is not governed by an isolated transducer. Heretofore, process models, which accept images or numerical descriptions thereof as input (e.g., the stochastic Perceptual Template Model, Dosher & Lu, 1999, *Vis. Res.* 39:3197), have proven incompatible with this failure of Birdsall linearization, unless they incorporate the principle of intrinsic uncertainty, which asserts that detection is governed by the maximum activity in several independent mechanisms (Klein & Levi, 2009, *J. Opt. Soc. Am. A* 26:B110). Another process model incompatible with the failure of Birdsall linearization is Watson and Solomon's (1997, *J. Opt. Soc. Am. A* 14:2379) model of visual contrast gain control and pattern masking (Figs. 1a – 1c). However, Birdsall linearization can disappear with this one simple trick: Allow the visual signals elicited by each image to be pooled prior to the comparison (i.e., the subtraction) between images (Fig. 1d). In this case, psychometric slopes remain high, even when external noise elevates threshold by more than 20 dB, without any detrimental effect to the quality of the model's fit to contrast-discrimination thresholds in the absence of noise (Fig. 1e). The take-home message: Steep psychometric slopes do not necessarily imply intrinsic uncertainty; contrast-gain control is another possibility.

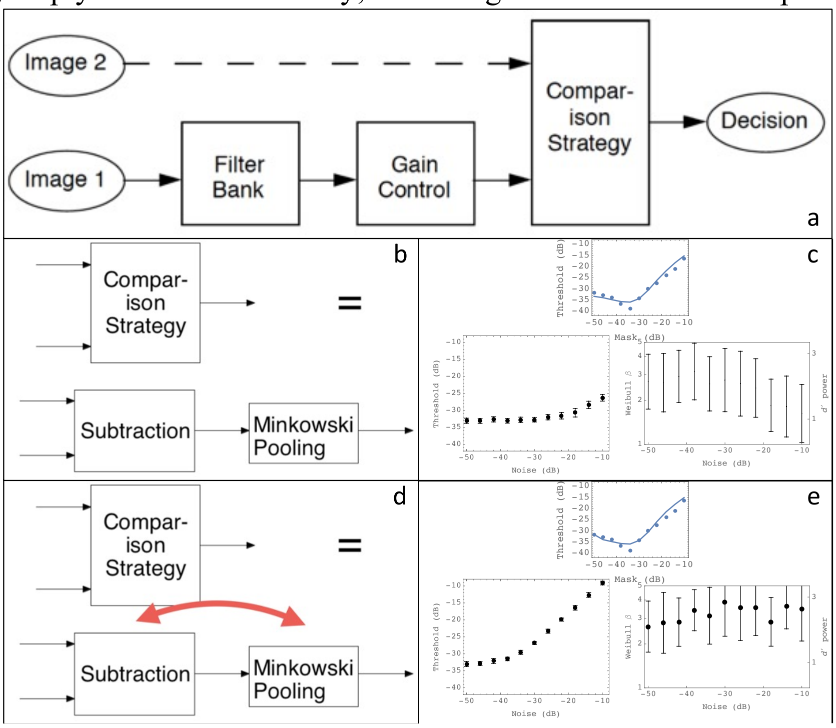

Fig. 1. Modified pattern-masking model, free from Birdsall linearization. Panel a (taken from Watson & Solomon, 1997) diagrams a process model for pattern discrimination. Panel b shows a detail of the original comparison strategy. When calibrated with observer KMF's data from Foley and Boynton's (1994, *Proc. SPIE* 2054:32) analysis of two-alternative, forced-choice pattern masking, this model predicts a decrease in psychometric slope when a Gabor target is masked by a random sample of ("twinned") white noise that is added to both images (panel c; NB: error bars contain 2 SD from Monte Carlo simulations). Psychometric slopes do not decrease (panel e) when simulations are run with the modified comparison strategy shown in panel d.