Paul Whittle (1986) investigated the smallest variation in luminance (ΔI) required to discriminate a test patch with luminance (I_t) from a reference patch with luminance (I_r). Both are viewed on a uniform background (I_b). When $I_r = I_b$ the task reduces to detection thresholds (see Fig. 1B for a schematic). Discrimination thresholds, over the approximate luminance range of a CRT monitor are shown in Fig 1A (red triangles) and exhibit two troughs, one at the lowest reference luminance tested and another around the background luminance level. This pattern of results has lead some authors to propose two separate mechanisms, one more sensitive to low luminance levels and another sensitive to the contrast between the test and reference stimuli and the background (e.g. Nagy & Kamholz, 1995). Paul Whittle modeled this effect using two separate equations, one for positive pedestals ($I_r > I_b$) and another for negative pedestals ($I_r < I_b$). In this paper we offer a different explanation. The operation of the model is illustrated in Fig 2A and begins with the threshold versus intensity (TvI) function for detection thresholds denoted by the blue line. To estimate discrimination thresholds we apply a gain term that increases thresholds away from the background luminance level. Thus $\Delta I = TvI(1 + kC)$, where C is the contrast between the reference luminance and the background and k a term that controls the degree of gain. As can be seen in Fig. 1A, a non-zero value of k gives rise to a pattern of threshold similar to those observed by Paul Whittle.

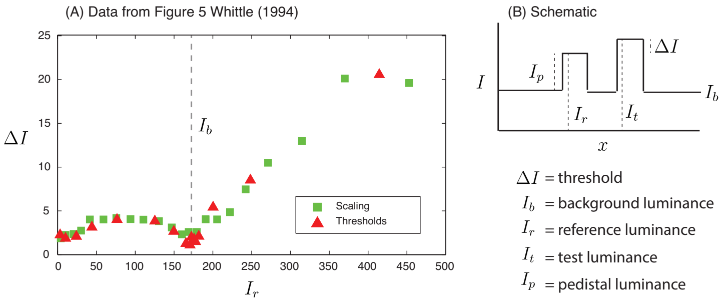

Figure 1 (A) Discrimination thresholds from Whittle (1986). (B) Schematic of the experimental stimulus.

Arguably, the most important observation by Whittle (1992) was that the discrimination thresholds aligned well with those obtained in a supra-threshold brightness experiment. In this experiment subjects manipulated the luminance of a series of patches until they appeared to transitions for bright to light with equal steps. The data from two versions of such an experiment is plotted in Fig 1A and Fig 1B. In Fig 1A the luminance different between adjacent patches (green squares) is plotted against the discrimination thresholds (red triangles) and a close alignment is found. We conducted a number of similar experiments. In fig 2(B) we show the data from one such experiment (open circles). The solid curves are the integral of $1/\Delta I$. As can be seen Fechner integration of the model discrimination thresholds produces a close match to the supra-threshold brightness function. Note that a TvI function that deviated from Weber's law especially at low luminance levels was required to achieve a good quality fit.

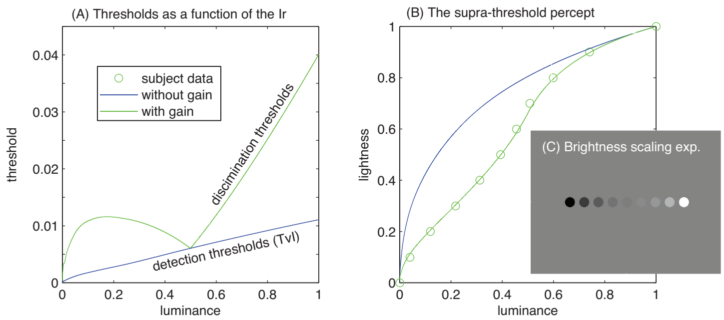

Figure 2 (A) Blue line denoted the threshold versus intensity function and the green line discrimination thresholds after the application of a gain mechanism. (B) The integral of one over the thresholds in (A) with corresponding colors. (C) Screen print the experimental stimulus used to obtain the open green

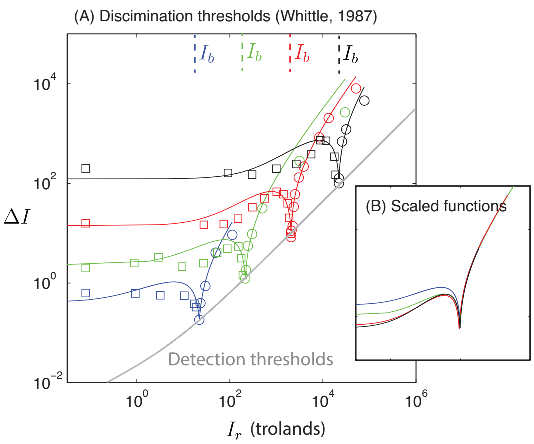

Figure 3 (A) Discrimination thresholds from Whittle (1987) for four background luminance levels denoted by the blue dashed lines. The solid line are the model's discrimination thresholds and the gray line the detection thresholds from Hecht (1924). (B) Scaled functions.

Whittle investigated discrimination thresholds for four different background luminance levels. Our model can replicate this data with a single value for k (although the impact of scatter must also be considered). However, to obtain accurate predictions we must use a TvI function that exhibits realistic non-Weber like behavior. To do so we take the TvI data collated in Hecht (1924). This TvI function increasingly deviates from Weber like-behavior at lower luminance levels thus producing different shaped function as shown in the inset.

Finally, we repeat the supra-threshold experiment for a number of non-uniform background luminance conditions. In figure 4 we show one such set of conditions composed of salt and paper noise of differing percentages. In the case of multiple background luminance levels, the model requires a gain terms of each background level. Thus the solid lines are two parameters fits. As can be seen, a diverse set of curves can be produced that accurately reflect our experimental data.

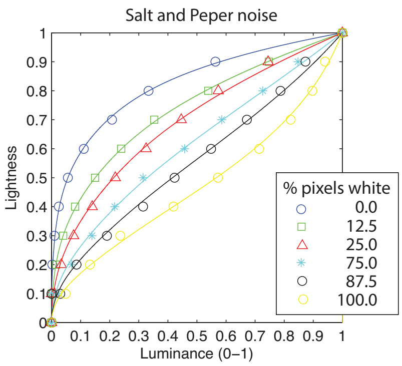

Figure 4 Lightness as a function of onscreen luminance for salt and pepper backgrounds.

Conclusion: The model discussed here has a number of implications for research into luminance perception. First, it suggests that discrimination thresholds rather than detection thresholds should be used in conjunction with Fechner integration to estimate the supra-threshold percept. Second, through the application of a very simple mechanism we can produce a diverse set of curves, including those that do and do not exhibit 'crispening'.