In the 'phantom' illusion (Galmonte, Soranzo, Rudd, & Agostini, submitted), *either* an incremental or decremental target surrounded by a luminance gradient can to be made to appear as an increment or a decrement, depending on the gradient width. For wide gradients, incremental targets appear as increments and decremental targets appear as decrements. For narrow gradients, the reverse is true.

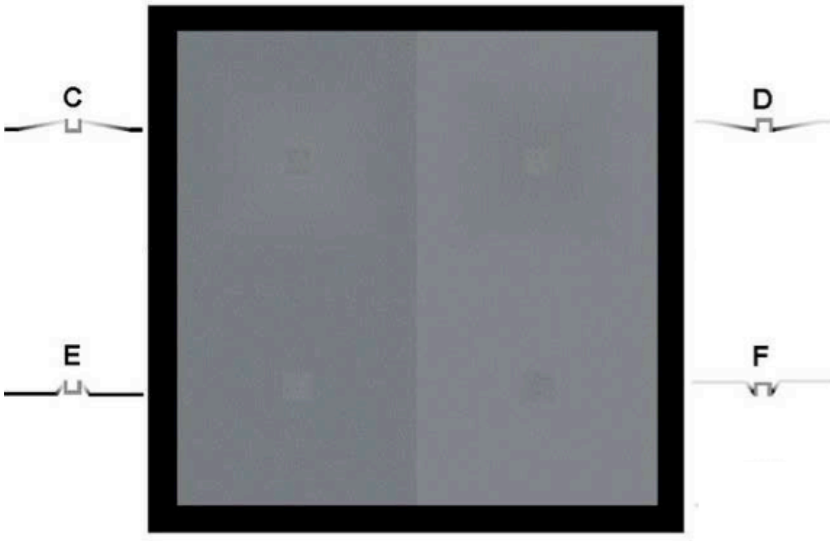

Figure 1. The Phantom Illusion

I model these phenomena with a two-stage neural lightness theory (Rudd, 2013, 2014) in which local steps in log luminance are first encoded by oriented spatial filters operating on a log-transformed version of the image; then the filter outputs are appropriately integrated along image paths directed towards the target. Contrast gain control adjusts each filter's gain on the basis of the outputs of other nearby filters. The weighted contribution of each filter to the target lightness decays exponentially with distance, as do the strengths of the between-filter gain modulations.

Rudd (2010) applied this theory to the problem of disk lightness in a disk-annulus display. In that case, the equation for the disk lightness is

$$\Phi_D = w_1 g_1 (D - A)(1 \pm k_2 g_2 \left| A - B \right| e^{-r/r_0}) + w_2 g_2 e^{-r/q_0} (1 \pm k_1 g_1 \left| D - A \right| e^{-r/r_0}) \ ,$$

where D, A, and B are the luminances of the disk, annulus, and background field in log units; r the annulus width; r_0 and q_0 are space constants; g_1 and g_2 the gains of the filters encoding the disk-annulus and annulus-background edges; w_1 and w_2 are weights assigned to the filters responding to the disk-annulus and the annulus-background edges in the computation of target lightness; and k_1 and k_2 are constants depending on the stimulus geometry. Here, I generalize the math model by assuming that the oriented filters respond to both edges and gradients. Their outputs are proportional to either the step in log luminance at the target border or the gradient slope at locations within the gradient. The neural assumptions are unchanged.

Fig. 2 plots the simulated lightnesses of incremental and decremental targets as a function of gradient width and reproduces the illusion. In this simulation, I assumed that the gain applied to decremental luminance steps is 3 times larger than the gain applied to incremental luminance steps; and that inwards and outwards gain controls have opposite signs. These ancillary assumptions are motivated by previous data and theory (Rudd, 2010, 2013), but they are not required to reproduce the qualitative effects of the wide and narrow gradients on lightness.

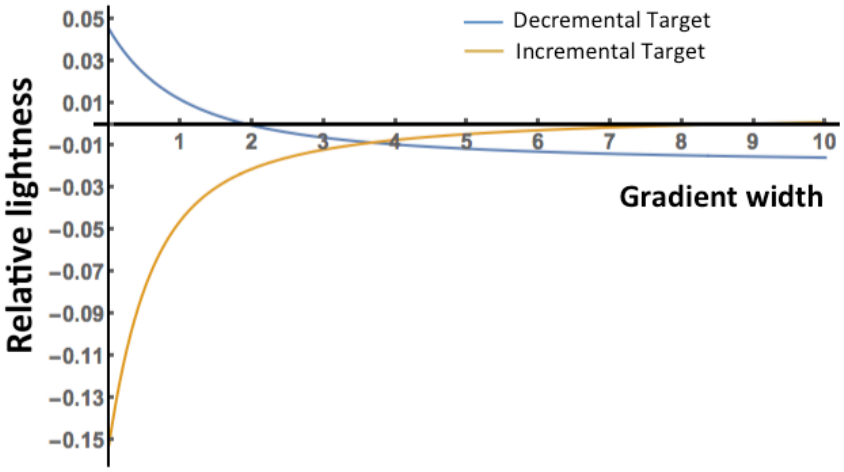

Figure 2. Relative lightness of the incremental and decremental squares as a function of gradient width (simulation results).