View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Purdue E-Pubs

Minjung Kim, Jason M. Gold and Richard F. Murray
[1]Department of Psychology and Centre for Vision Research, York University, Canada
[2]Department of Psychological and Brain Sciences, Indiana University Bloomington

Abstract. Lightness constancy is the ability to maintain a stable perception of surface lightness across lighting changes. Typical lightness experiments involve making perceptual matches or measuring thresholds (PSEs); here we took the novel approach of measuring classification images (Ahumada, 2002; Murray, 2011) to understand which image features contribute to lightness perception.

Different theories of lightness perception emphasize different image features as being critical. Adelson (1993) emphasizes X-junctions (Beck, Prazdny & Ivry, 1984) as a cue to lighting boundaries; Shapiro and Lu (2011)'s high-pass filter emphasize isotropic surrounds; Blakeslee and McCourt's (1999) oriented difference-of-Gaussians (ODOG) is sufficiently complex that it is difficult to know what the important features might be. We expected model classification images to discriminate between different model predictions.

We used the argyle illusion (Adelson, 1993) as our 'fruit fly' for model evaluation. In this illusion, some patches appear lighter than others, though they are of the same physical luminance (Fig. 1). We chose this illusion because it is one of the strongest known lightness illusions, and has also consistently resisted explanations by low-level models (e.g., Blakeslee & McCourt, 2012).

We implemented four models, some our own and some by other authors: a local contrast model, an X-junction model (inspired by Adelson, 1993), the ODOG model (Blakeslee & McCourt, 1999), and a high-pass filter model (Shapiro & Lu, 2011). We measured PSEs (Fig. 2) and classification images (Fig. 3) for human and model observers.

Whereas human observers' classification images showed a role of local contrast that depended on the shape of lighting regions (Gilchrist et al., 1999), none of the models behaved even qualitatively like humans. Even the X-junction model failed, suggesting that though X-junctions may be important for the perception of lighting boundaries, they are not directly used to compute lightness.

Our results point out the need for a model that is conceptually distinct from those currently used in the field. For both human and model observers, classification images complement PSEs for understanding how a visual illusion works. We encourage other authors to use classification images to guide future model development.

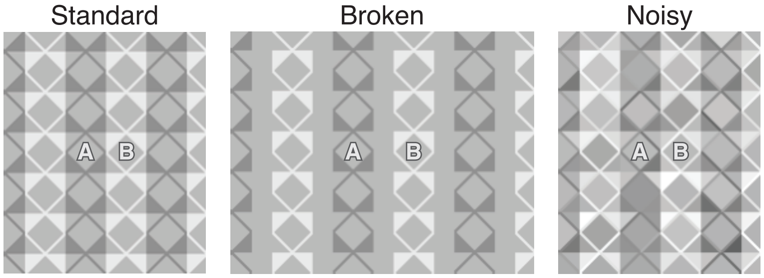

Figure 1. ***Standard***. Diamonds A and B have the same luminance, but A appears much lighter than B. Adelson's (1993) explanation is that A appears to be under a dark vertical transparency but B does not, and therefore, the visual system makes the nonconscious inference that A has a higher reflectance than B. ***Broken***. Without the vertical strips, A and B appear the same or similar. ***Noisy.*** Used for classification image experiment. For all experiments, the task was to choose the lighter diamond.

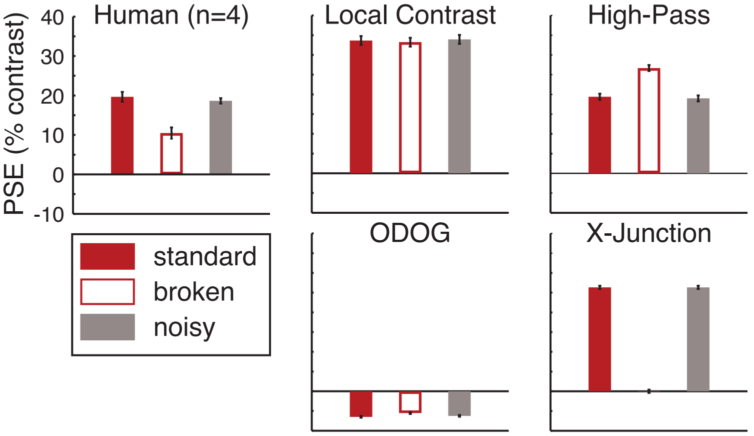

Figure 2. Results of the PSE experiment. Higher PSEs mean greater lightness illusion. Local contrast, high-pass, and ODOG observers failed to show this pattern. The X-junction observer only showed the correct response by design.

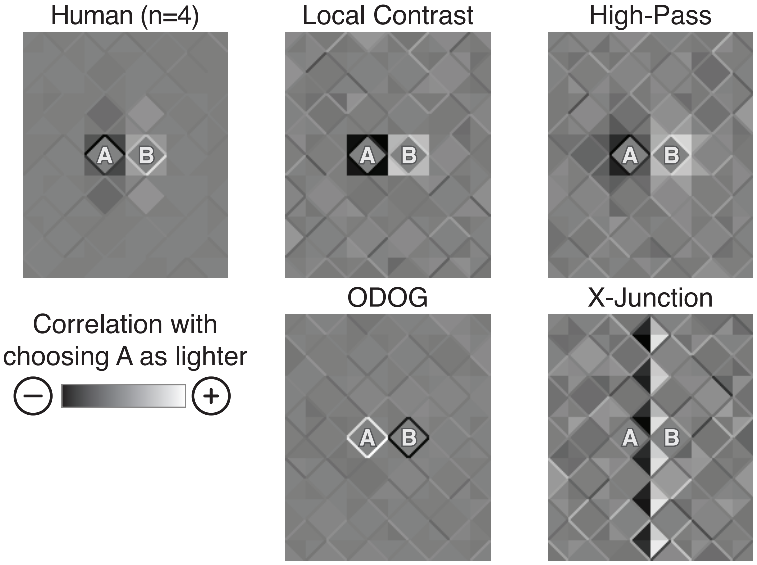

Figure 3. Results of the classification image experiment, showing the degree to which a patch correlates with choosing A as whiter. Human observers rely on the contrast of diamonds A and B with respect to local neighborhood, notably diamonds above and below A and B. None of the model observers showed the correct response.

Corresponding author: Minjung Kim
mkim85@yorku.ca