Supporting Information

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Text S1: Direction of Light Source

Because in the matching experiment the lightest part of the objects was always nearest to the matching disk, this configuration might have produced the spatial bias in the fixation distributions. We therefore tested whether the object luminance causally drives the observers' gaze. To this aim we repeated the color-matching experiment inverting the light gradient of the objects while the mean illumination was kept roughly constant. Seven observers participated in this experiment. When the object was brighter on the left side, the fixations tended to focus on the left compared with the original experiment, when the light had the opposite gradient (Fig. S2). This finding means that fixations are driven by illumination and that observers tended to fixate points brighter than the mean of the object.

Text S2: Retinotopic Adaptation

Before concluding that the sampling strategy of our visual system drives our estimation of lightness, we have to exclude a simpler adaptation explanation. In the forced fixation experiment observers saw the image only at a constant retinal position. This aspect could cause retinotopic adaptation specific to the foveal area. The fact that observers tended to set a darker color after fixating the darker part of the image could be explained by the fact they were less light-adapted and thus the matching disk appeared brighter. The opposite could be true in the bright fixation condition. To control for this possibility we repeated the gaze-contingency experiment with parafoveal matches. The matching disk was presented at the center of the computer screen only when the observers (four naive undergraduate students) fixated a spot on the right side of the screen. We chose the position of the fixation point and matching disk so as to make sure that the retinal location of the matching disk was adapted to dark while the object was in the fovea. We chose three objects with different colors but similar shape (candles), so that all objects covered the same retinal area. To increase the effectiveness of our experimental manipulation, we chose more extreme points in the objects' luminance distribution (5th and 95th percentiles) compared with the previous forced-fixation experiment. Percentiles have been taken from the low-pass filtered-image luminance distributions to avoid local minima. The results qualitatively matched the ones from the previous experiment. The effect of fixation condition is highly significant (left light source condition: $P < 0.001$; right light source condition: $P < 0.001$) despite the fact that luminance sensitivity decreases in parafoveal view (1). Thus, local adaptation cannot explain the effect of fixation region.

Text S3: Luminance or Reflectance Matches

Observers were presented with gray-scale images of the same objects used in the forced-fixation experiment: the cone, the candle, and the wool ball. The images were displayed on the computer screen only when the observer was fixating a chosen point (dark or light). The images were presented on the left part of the screen. Sixteen real paper chips defined by different reflectances from black to white were randomly placed on a board on the right part of the screen. The board was illuminated by a nearby bulb lamp, which produced a strong illumination gradient (about 30 candelas range on the lightest chip). The observers' task was to choose the chip whose material appeared most similar to the object's material. The chips were presented in 10 different random spatial locations. The random placement of the chips in the illumination gradient added luminance noise, producing dissociations of reflectance and luminance (Fig. S5). We computed the effect of fixation position on the reflectance selections. In the dark fixation (DF) condition, observers chose chips with lower reflectance than in the light fixation (LF) condition.

To ensure that observers were indeed judging reflectance in this experiment, we asked three observers to sort the chips in terms of their brightness and in terms of the lightness of their paint. Observers were practically unable to distinguish between perceived shade of the paint and perceived brightness (Spearman's correlations between the rankings in the two different tasks for the three observers: 0.991, 0.998, and 0.989). Because of the illumination gradient, there were cases where reflectance and luminance would lead to differences in the rankings. When this was the case, observers sorted the chips according to their reflectance in more than 85% of all cases, irrespective of their instruction. Our results indicate that observers discarded the illumination and estimated the chips' lightness before choosing the one matching the fixated area of the object.

1. Greenstein VC, Hood DC (1981) Variations in brightness at two retinal locations. *Vision Res* 21(6):885–891.

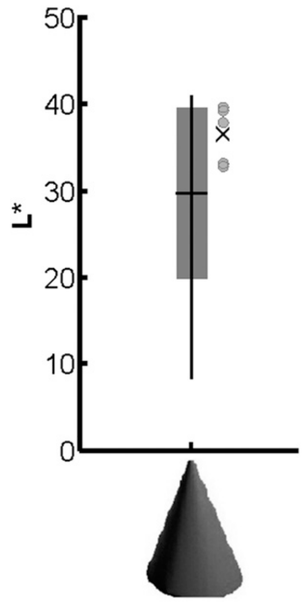

Fig. S1. Achromatic objects. Lightness matches by five observers for a gray cone in the same setup as the original free looking experiment. Gray circles represent the average matches; the black cross represents the average across the observers. The gray bar represents the mean ±1 SD and the black vertical line represents the range of the distribution of L* within the object. Five observers participated in this experiment. The matches are all above the mean of the object and close to the upper border of the cone luminance range, similarly to what we observed for the other objects when observers were doing full color matches. The average of the gray cone matches is significantly higher than the object's mean luminance ($t_4 = 4.61$, $P < 0.05$). The median luminance of the fixated regions was significantly higher than the median of the luminance distribution (binomial test, 184 of 307, $P < 0.05$).

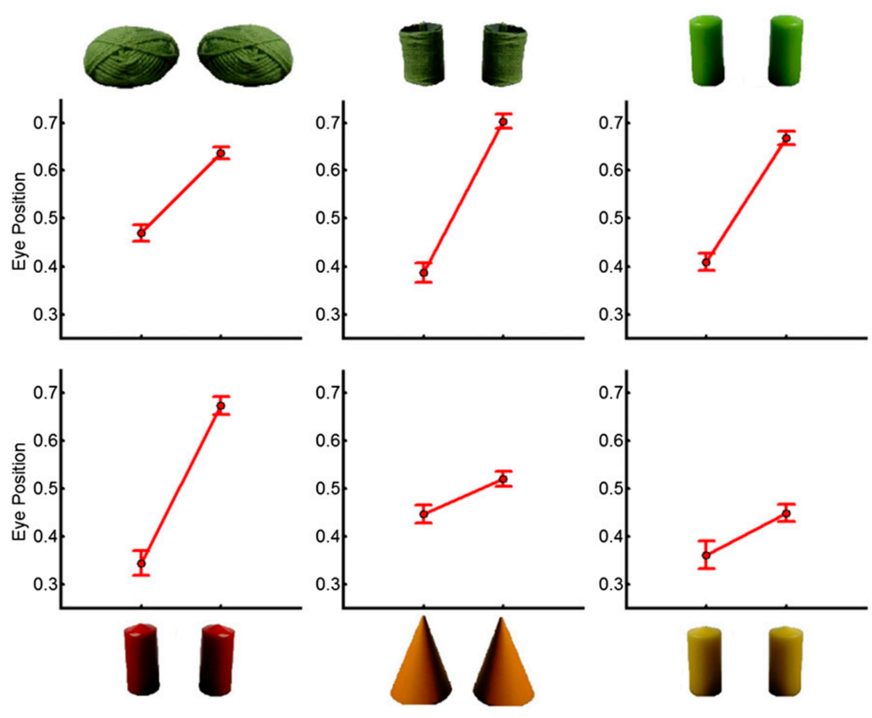

Fig. S2. Direction of light source. Each diagram represents data for one object illuminated from the left and from the right, respectively. For each fixation, a horizontal relative position has been computed from the extreme left point to the extreme right point of the object (0 and 1, respectively). Red points represent the mean of all recorded fixations. Vertical bars are the SEMs. When the object was brighter on the left side, the horizontal fixation position distribution was shifted to the left compared with the case when the light had the opposite gradient (original matching experiment).

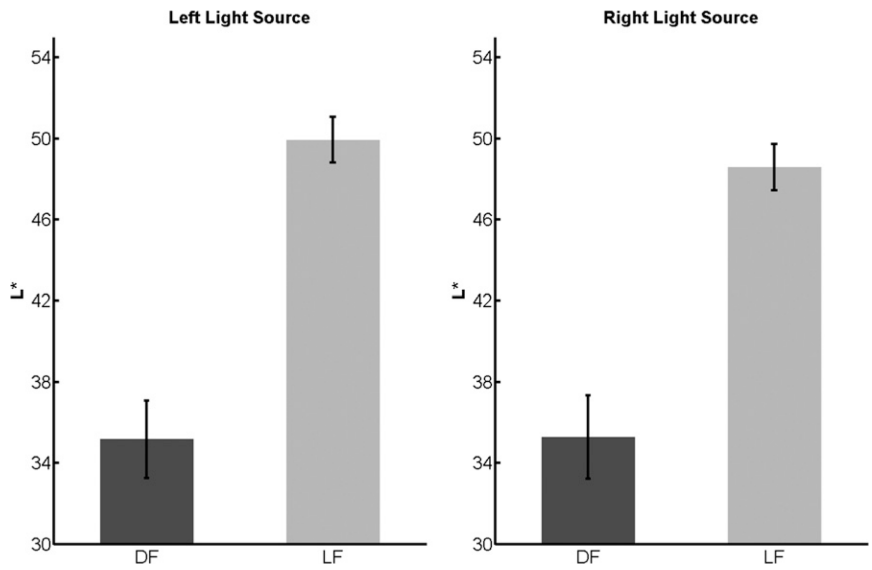

Fig. S3. Retinotopic adaptation. The two panels represent the matches in the two fixation conditions with the light source coming from left and right, respectively. Dark bars represent the observers ($n = 4$) averages in the DF condition and light bars in the LF condition, black vertical lines represent the SE.

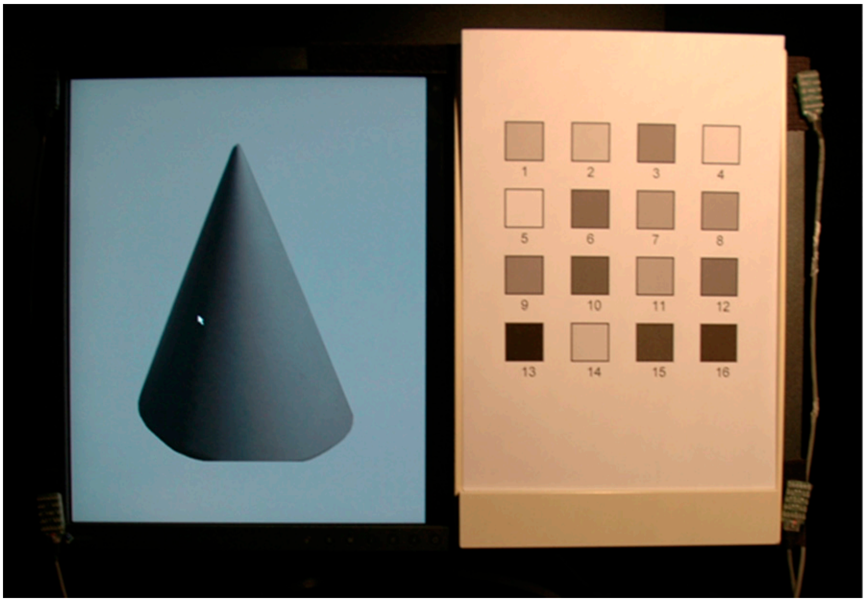

Fig. S4. Reflectance experiment setup. The images were presented on the left part of the screen. On the right part 16 real paper chips, defined by different reflectances from black to white, were randomly placed on a board illuminated by a bulb lamp standing quite close to the board, which produced a strong illumination gradient (about 30 candelas range on the lightest chip).

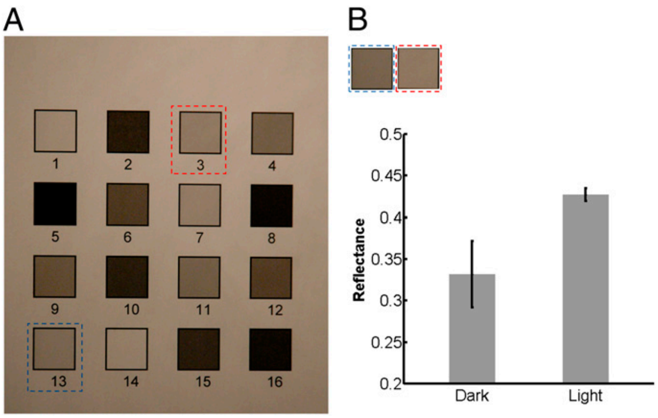

Fig. S5. Paper matches. (*A*) One of 10 random arrangements of the paper chips on the page. Observers had to choose the chip they thought had the same material as the object displayed on the nearby computer screen. (*B*) Results of the reflectance selection experiment. In the DF condition, chips with lower reflectance were selected than in the LF condition. The figure also illustrates the dissociation between lightness and brightness. In the photo on the left, chip 3 (red frame) looks darker than chip 13 (blue frame), and it was consistently ranked lower both in terms of lightness and brightness by the three observers. However, chip 13 has a higher reflectance than chip 3 (74% and 60%), although its luminance is lower (29 cd/m^2 and 44 cd/m^2). Indeed, if viewed in isolation, chip 13 looks darker than chip 3 (*Upper* central squares).