Color perception in a 3–D scene of one reflectance

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1.   INTERREFLECTIONS IN A BLACK & WHITE SCENE OF ONE REFLECTANCE

Surfaces in a 3–D scene are illuminated **directly** by light sources and also **indirectly** by each other, via interreflections.

image   =   "direct"   +   "indirect"
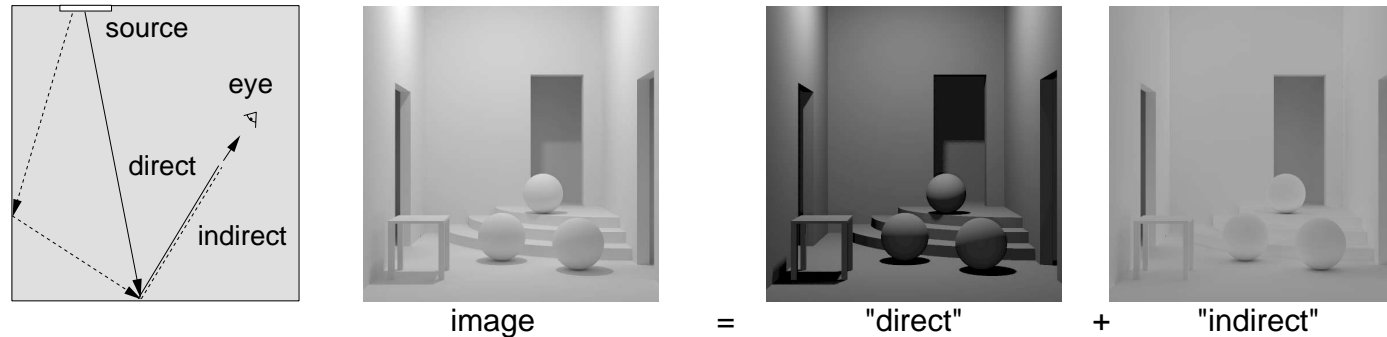
The contribution of "indirect" depends on the paint.   If the paint is white then "indirect" will be relatively bright, but if the paint is black then "indirect" will be relatively dark.

## 2.   INTERREFLECTIONS IN A COLORED SCENE OF ONE REFLECTANCE

If the paint is colored, then each reflection changes the spectrum shape. Let $e(\lambda)$ be the illuminant and let $s(\lambda)$ be the surface reflectance.
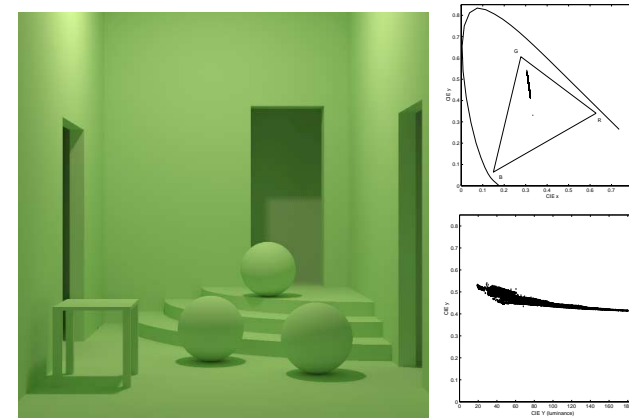
$$\text{"direct"} \sim e(\lambda) s(\lambda)$$

$$\text{"indirect"} \sim e(\lambda) s(\lambda)^2 + e(\lambda) s(\lambda)^3 + e(\lambda) s(\lambda)^4 + ...$$

*i.e.*   2 bounce   +   3 bounce   +   4 bounce   + ...

The shape of "indirect" depends more on $s(\lambda)$ than on $e(\lambda)$. Thus, to infer the color of the paint, an observer should compare the shadowed and unshadowed regions.   In the shadows, only "indirect" light is present.

a purple painted room under a green source

a green painted room under a purple source
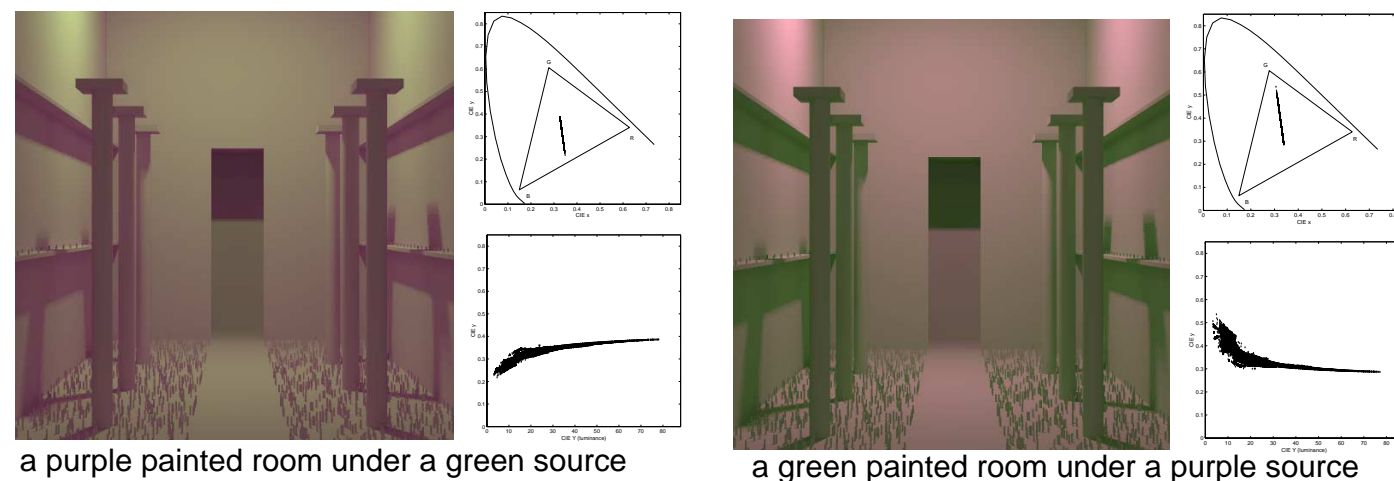
3.   PSYCHOPHYSICS EXPERIMENT

a green painted room under a white source
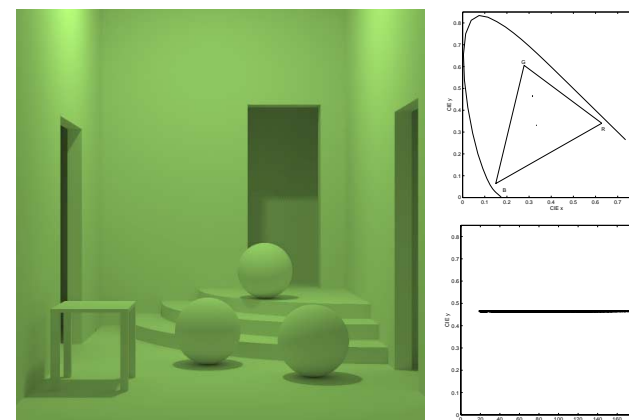
a grey painted room under a green source

Q: Can naive observers distinguish a grey painted room from a color painted room ?
A: Yes they can!

Stimuli: Pairs of hyperspectral images were rendered using state–of–the–art computer graphics software (RADIANCE). This software accurately computes interreflections by solving the radiosity equation. Each pair of images consists of a color painted room under white light and a grey painted room under colored light.   Mean luminance (CIE Y) and RMS luminance contrast were identical within pairs.   For each rendered hyperspectral image, a pixel–by–pixel color match was computed between the rendered image and an RGB image displayable on a given calibrated CRT.

Procedure: On each trial, the observer was allowed to toggle between two images of a pair. The task was to decide which image had the colored paint (2AFC).

Design: 14 naive observers viewed 8 pairs each (4 hues x 2 lightnesses).

Results: 5 observers scored 8/8. 1 observer scored 0/8. 8 observers scored between 5/8 and 7/8.

Conclusion: The two types of room are perceptually different. Most observers are able to adopt a consistent (and usually correct) strategy for interpreting the differences in terms of the spectrum of the illuminant versus the surface.

4.   CONCLUSIONS

In a scene of one reflectance, the brightest regions indicate the color of the source and the darkest regions (e.g. shadows) indicate the color of the surface. Observers can use this information to disentangle surface color from illuminant color.   **No theory of color vision even attempts to account for this ability !**

5.   REFERENCES

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