CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
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Project Number
S0413

Project Title
Effects of Shadows, Local Contrast, and Geometric Knowledge on Perceived Lightness

Abstract

Objectives/Goals
To perceive the lightnesses of surfaces, the brain not only takes their luminances into account but also the scene context. The "checkershadow illusion" probes such contextual effects. In this illusion, a white square of a chessboard under a shadow appears lighter than a black square outside the shadow even if the luminance of the latter is higher than that of the former. This illusion has been hypothesized to arise from the local contrasts of the squares, the brain's knowledge of the chessboard geometry, or the knowledge that shadows darken surfaces. This study tested these three hypotheses.

Methods/Materials
The psychophysical point of subjective equality was measured in five human subjects as a function of the intensity of the shadow. The original images were photographed chessboards with or without a shadow. The shadow was extracted and manipulated with Photoshop, and the psychophysics performed with MATLAB.

Results
In the "checkershadow illusion" of this experiment, the luminance of the white square was 20% that of the black square when they appeared equally light. Manipulating the shadow to be physically unrealistic caused this percentage to increase to 30%. In turn, this percentage of subjective equality was increased to 55% when the local contextual intensities were also equalized. Therefore, even without shadow and local-context effects, the luminance of the white square was lower that of the dark square when both appeared equally light.

Conclusions/Discussion
In conclusion, shadows, local contrasts, and geometrical knowledge all provide contextual information used in different degrees by the brain in the computation of lightness. A surprising result was that shadows were relatively unimportant as compared to the other tested image attributes in controlling the brain's perception of lightness. Local contrast and geometrical knowledge had much larger effects on this perception. It is exciting to see that the knowledge of a chessboard may affect such a fundamental property of the human visual system such as the perception of lightness. Chessboards are manmade structures that had no impact on the evolution of the brain. Thus, it can be concluded that the brain's processing of lightness undergoes perceptual learning for manmade structures.

Summary Statement
By using psychophysical techniques, it was demonstrated that contextual information in images such as shadows, local contrasts, and geometric knowledge, affects how the brain perceives surface lightness.

Help Received
Dr. Norberto Grzywacz from USC advised me on the design of the project and taught me the use of Photoshop and MATLAB; Members of my family were the psychophysical subjects in the project; Mother helped with design of poster