

Title: Investigation on Light Effect on Spatial Illusion Resulting from Forced Perspective

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Introduction:

Linear perspective is a drawing system that can transform the geometry from the conceptual form to perceptual, and thus is an essential tool for designers to predict the spatial perception of the proposed designs of constructions. Linear perspective is also identified as an effective pictorial depth cue that can provide the visual information to retrieve the three-dimensional sense of depth from both the two-dimensional retinal images and the drawn pictures [5] [6]. As a result, it has been used as an effective design strategy to create forced perspectives that can exaggerate depth perception of architectural scenes. Light has also been observed to influence the perceptual judgment of depth in an architectural scene. Luminance contrast has been proven, through perceptual studies conducted using the perceptually realistic computer-generated environment, to be an effective depth cue that can create illusory depth effects [7]. In this study, the interrelationship of the size-related depth cue of forced perspective and the tone-related depth cue of luminance contrast was investigated in a threedimensional setting. Architectural space of Colonnade Spada was designed based on the forced perspective to create illusory depth [1]. The original design has a series of skylights that no longer exist. For this study, the Colonnade Spada (with and without skylights) was simulated in a computational environment. Psychophysical experiments were then conducted to investigate whether the luminance contrast introduced by the skylights would affect the illusory depth effect created by the distorted structural configuration, which is caused by forced perspective.

Main Idea:

According to the size-distance invariance hypothesis, the perceived size of an object can be derived from its perceived distance. Size has therefore been proposed as an alternative measurement in visual matching to study depth perception [4]. Fig. 1 illustrates the experiment setup of this study. The Colonnade Spada was modeled in a digital environment in three different ways: the existing trapezoidal configuration of the gallery with and without skylights, and the rectangular configuration derived reversing from the forced perspective of the trapezoidal configuration without skylight. At the far end of the configurations is a courtyard; a sphere (serving as the visual target for the experiment) appears to float within the courtyard about 150 cm above the floor. The figure of a person standing at the front end of the configuration and looking towards the visual target represents the point of the observation. The distance between the observer and the visual target in the rectangular configuration of the Colonnade was twice the distance between the observer and the target in the trapezoidal configuration. The visual target was 50 cm in diameter in the rectangular configuration, but was 25 cm diameter in the trapezoidal ones. Because the visual target in the rectangular configuration was twice as far as the visual target in the trapezoidal configuration, the size of the visual target was doubled so that the visual targets between the three scenes would have the same apparent size.

Three sets of experiments were developed to explore the effects of geometrical configuration and lighting condition on perceived distance. The first one was a comparison of a fixed-size (50 cm) visual target in the trapezoidal configuration (without skylights) and the nine levels of visual target size in the rectangular configuration. The nine levels of visual target size were derived from reducing and increasing the size of the original 50 cm target at 5-percent intervals. This comparison was designed to explore the illusory perspective depth effect resulting from distorted geometrical construction. The second experiment was a comparison between a fixed-size (50 cm) visual target in the trapezoidal configuration (with skylights) and nine levels of visual target size in the rectangular configuration. This, on the other hand, was intended to explore the influence of lighting patterns (introduced by the presence of skylights) on the illusory depth effect. The third one was a comparison between a fixed-size (50 cm) visual target size also in the rectangular configuration. This last experiment serves as the baseline that the first two experiments will be compared with.

Method of constant stimuli was used to measure the perceived sizes of the visual targets. The data collected from the psychophysical experiments were analyzed using Probit analysis. Fig. 2 illustrates the results. The horizontal dashed line is the difference threshold, and where the psychometric function intersects with this line is the point of subjective equality (PSE) [2] [3]. The PSE represents the physical value of the variable-size visual target that is perceptually equal to the fixed-size visual target. The PSE values for the rectangular configuration without skylights, the trapezoidal configuration without skylights, and trapezoidal configuration with skylights are 50.479 ± 0.182 cm, 49.421 ± 0.184 , and 47.379 ± 0.194 cm, respectively. The measured perceived size decreased around 2.1% from "Rectangular configuration without skylights" condition to "Trapezoidal configuration without skylights". According to size-distance invariance hypothesis, the perceived distance of the visual target in "Trapezoidal configuration without skylights" condition is 2.1% shorter in depth compared to the "Rectangular configuration without skylights". However, the measured perceived size of the visual target in "Trapezoidal configuration without skylights" condition decreased 4.1% compared to the condition of "Trapezoidal configuration without skylights". Suggesting that additional skylights may further reduce the depth effect of the force perspective.

Conclusion:

This study demonstrated the use of computer simulation in investigating the depth effect of the variable that is difficult to manipulate in a real setting. Computer simulation was used to generate the experiment scenes because it allows for easy and precise replication, as well as modification, of the geometrical configuration. The complex architectural details of the Colonnade Spada would be difficult and expensive to reproduce (whether full scale or at a smaller scale) for an experiment like this, so computer simulations can be quite cost-effective but without sacrificing detail or accuracy. However, since this study employed an indirect method of measuring the perceived distance by measuring the perceived size, the findings can only account for possible trend interpretation. Furthermore, the quality of daylighting varies from time to time, so the simulations in this study cannot account for all sky conditions. Therefore, this study cannot fully conclude the quantitative depth effect of the forced perspective resulting from the trapezoidal configuration and the presence of skylights in Colonnade Spada. However, an interesting finding from the experiment results is that additional visual information (such as sharp sun patches) can reduce the depth effect of the forced perspective, suggesting that the presence of skylights can make the illusory depth effect more unpredictable.

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Fig. 1: Architectural configurations and test scenes.



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