Effect of Display Technology on Perceived Scale of Space

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Objective: Our goal was to evaluate the degree to which display technologies influence the perception of size in an image.

Background: Research suggests that factors such as whether an image is displayed stereoscopically, whether a user's viewpoint is tracked, and the field of view of a given display can affect users' perception of scale in the displayed image.

Method: Participants directly estimated the size of a gap by matching the distance between their hands to the gap width and judged their ability to pass unimpeded through the gap in one of five common implementations of three display technologies (two head-mounted displays [HMD] and a back-projection screen).

Results: Both measures of gap width were similar for the two HMD conditions and the back projection with stereo and tracking. For the displays without tracking, stereo and monocular conditions differed from each other, with monocular viewing showing underestimation of size.

Conclusions: Display technologies that are capable of stereoscopic display and tracking of the user's viewpoint are beneficial as perceived size does not differ from real-world estimates. Evaluations of different display technologies are necessary as display conditions vary and the availability of different display technologies continues to grow.

Applications: The findings are important to those using display technologies for research, commercial, and training purposes when it is important for the displayed image to be perceived at an intended scale.

Keywords: display evaluation, space perception, virtual environments

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INTRODUCTION

The successful use of three-dimensional computer graphics in research, commercial, and training situations requires users to perceive the scale of space appropriately. We refer to this concept as *perceptual fidelity*—the extent to which viewers perceive the absolute scale of virtual environments (VEs) in a manner consistent with how scale is perceived in the real world. The absolute scale of a VE can be understood by evaluating many geometric properties of the scene, such as distance and size. Although there is extensive research on the perception of absolute distances in VEs (Kunz, Wouters, Smith, Thompson, & Creem-Regehr, 2009; Loomis & Knapp, 2003; Richardson & Waller, 2007), there is relatively little known about how absolute size is perceived in VEs. *Absolute* refers to properties of the environment that are defined in terms of some fixed standard (e.g., centimeters) and are in contrast to relative properties that are specified in terms of comparisons (e.g., one object is half the size of another object). Perceived size is particularly important to perceive in many applications, including medical visualizations, architecture, virtual reality, and simulations for training. Moreover, each of these applications may require displaying an environment on markedly different technologies. Thus, the display technology may be an important factor that influences the perceived scale of space, and specifically perceived absolute size, in VEs. Does viewing the same image on different display technologies influence how accurately sizes in the image are perceived?

The goal of this paper is to evaluate how multiple immersive display technologies that vary in the way images are presented to the user—including a large-field-of-view (FOV) stereo head-mounted display (HMD), a smaller-FOV stereo HMD, and a back-projected screen-based display (BackPro)—may affect perceived scale