SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

The systematic review was developed to establish effective strategies to design immersive virtual environments using a head-mounted device to conduct behavioral research.

Designing immersive virtual environments for human behavior research

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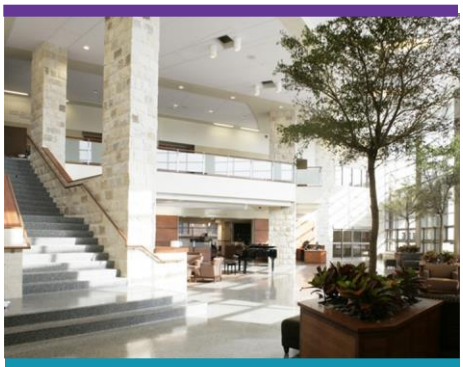
Key Concepts/Context

Immersive virtual environments (IVEs) are increasingly used in research to evaluate the role of the environment on behavior. The level of detail can influence the participant's sense of being in the virtual world, which influences the way a person interacts with the space. The results of this systematic review outline aspects of visual detail, context, social cues, the use of avatars, and other sensory detail that have been found to be important factors in successful IVE scenarios.

Methods

The researchers conducted a systematic review that focused on how the IVE was developed, rather than focusing on the final result with no explanation of the decision process. The researchers consulted with an academic librarian and established keywords and MeSH search terms. Terms were combined with "and" and "or" in specific combinations, and the search was conducted in four commonly used scholarly databases to identify 203 citations. Eligibility was determined through the inclusion criteria: peer-reviewed studies or conference proceedings; English-language; published before mid-2020; with study parameters of non-clinical populations; the use of head-mounted devices to evaluate behavior in the IVE; an approach to simulate a real environment; and necessary information to evaluate the design of the virtual environment. Specific behaviors were not part of the search terms or inclusion criteria. After determining eligibility, 61 full texts were reviewed to establish a final pool of 18 studies that were included in the review, all of which were published 2015-2020. Because the studies were conducted across different settings, with different parameters and variables of interest, a narrative synthesis of the findings was created instead of a quantitative meta-analysis.



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Findings

Findings cover environmental detail, context, social cues, participant tracking, and non-visual sensory information. The environmental detail includes features like furniture, textures, and lighting. However, while realistic rendering of the space can increase someone's sense of being there, it can have practical implications for increased development costs and a decreased frame rate when participants are in the IVE. Teams need to balance what detail is needed for the study objective, and what features are unnecessary. Too much detail can create a distraction for the variables being studied.

Context IVEs is derived through "looking behaviors," for example, a window help participants develop a mental model of their location. However, participants may also engage in exploratory behaviors that are not pertinent to the study. Any animated interactions (e.g., traffic) need to be realistic (e.g., speed) and the physical movement should match the virtual movement as closely as possible to foster the sense of reality.

If social aspects of behavior are important, digital avatars (agent-based) can be used to understand behaviors, but they need to be animated appropriately. In some instances, the avatar may be best as another person (human-controlled).

Self-avatars, an aspect of participant tracking, increase realism for the participant and are especially important for certain behaviors (e.g., crossing a road). Another aspect of participant tracking involves walking (and instructions to take into account the constraints of space [e.g., walk to the line]), as well as head turning, which influences spatial perception. Dramatic changes in head direction are not favorable for observing behavior in IVEs.

Lastly, non-visual sensory cues should be considered for their relevance. Tactile (haptic) feedback can be incorporated with real elements in the environment, while audio might be considered for weather, traffic, or voices. Smells should also be included if relevant to the study context (e.g., food smells).

Limitations

The authors note that, unfortunately, published studies often don't include the detail sought in this review due to page limits found in many academic journals. It wasn't possible to create search criteria for specific behaviors, and some of the inclusion criteria may have resulted in a reduced number of eligible studies. Within the small number of included studies, some of the aspects identified in the discussion were specific to the applications (e.g., food smell and eating behavior). While there are no healthcare examples, the findings are generalized to behavioral studies in a variety of settings.

Design Implications

When using IVEs to evaluate behaviors in the built environment, it is important to have an interdisciplinary team to plan, design, and implement a virtual reality study. For reasons of cost, time, technical limitations, and research goals, teams need to consider the appropriate level of detail to create a "real enough" world without including aspects of the design not relevant to the intended behavior or study objective.