

TRANSPORT FINDINGS

A Review of Street Representation Methods for Pedestrian Surveys

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Findings

This literature review explores researchers' approaches to visually representing street environments in surveys. We examine various methods, including in-situ surveys, immersive virtual reality, real-world videos, simulated videos, photographs, and illustrations. We briefly discuss the strengths and weaknesses of each representation method. We also develop criteria for evaluating representation methods, including participant effort, information quantity, and survey development costs. We find that most researchers do not describe detailed protocols or validate the comprehensibility of survey images. Selecting the most suitable representation method for a study involves a trade-off between researchers' goals and resources.

1. Questions

Transportation researchers are experts in travel behavior but not necessarily in visual representation methods. In our own research, we identified a need to determine the most suitable way to present street environments to survey participants but found no published guidance on this topic that considered the full range of possible methods. This rapid review identifies the scope of visual representation methods currently used to represent street environments and details protocol development and validation for such methods. We offer recommendations regarding the suitability of different representation methods given researchers' goals and resource constraints.

Therefore, we ask: what are the various ways of visually representing street environments in surveys to discern participant preferences, and what are the strengths and limitations of such methods?

2. Methods

We conducted a literature search using Google Scholar, the Web of Science, and the TRID (<https://trid.trb.org/>) database. Our keywords included the terms "Pedestrian," "Survey," "Image," "Video," and "Photo," "Visual Preference Survey," and "Pedestrian Stated Preference Survey."

With these results, we then went through two layers of filtering. The initial screening was by article title, then by article abstract. We included articles that included visual representations displayed to survey participants. We did not track our screening systematically, as the goal was a rapid rather than systematic review.

We examined 37 abstracts through this process and ultimately conducted detailed reviews of 27 publications. In Supplementary Table 1, we summarize the reviewed articles, including their title, the journal, their publication year (display order), the representation method employed, the design characteristics under consideration, image generation and guidance protocols, and any validation methods discussed. We requested images from all authors, and, where available, the table links to these original images in Zenodo.

3. Findings: Different Representation Methods for Presenting Street Environments in Surveys

Here, we briefly describe various representation methods, their strengths, and their drawbacks. Two notes apply across all image types. One, the publication of detailed protocols is the exception rather than the rule. And, two, few researchers attempted to validate the comprehensibility of their images. See the Supplementary Table for paper-specific details.

In-Person Surveys (In Situ, 2 reviewed)

The most information is available to survey participants when they are brought to or intercepted at the site of the street environment of interest (Rodriguez-Valencia et al. 2021; Rossetti and Hurtubia 2020).

The primary advantage of in situ interviews is that the participants can observe environments in the greatest detail. The disadvantage is that the researcher cannot manipulate environmental variables and is constrained in the recruitment of participants. Additionally, unfavorable weather could limit participant availability or alter their perceptions.

Immersive Virtual Reality (IVR, 5 reviewed)

We define Immersive Virtual Reality (IVR) as a 3D representation of street environments where the survey participant can freely look around in all directions and experience being surrounded by the simulated environment (Arellana et al. 2020; H. Lee and Kim 2021; Rossetti and Hurtubia 2020). Currently, interaction with immersive 3D environments involves wearing wrap-around VR glasses.

IVR environments expose participants to a detailed and realistic environment where they can view (and potentially listen) from multiple perspectives. They may also be able to explore such environments through movement (Kwon et al. 2022).

The development of IVR environments can be expensive and time-consuming (Arellana et al. 2020; Kwon et al. 2022). Survey participants must visit a lab and be monitored by a research assistant during participation (Arellana et al. 2020; Kwon et al. 2022).

Real-World Videos (3 reviewed)

Compared with IVR, videos only represent a single point of view and do not allow active exploration of the environment. Compared with photos, videos are better at capturing dynamic elements such as speeds and traveler interactions (Ling et al. 2014).

Real-world videos are constrained to environments accessible by the research team. Therefore, it may be challenging to represent all environmental variables of interest.

Simulated Videos (3 reviewed)

Various 3D simulation software's, such as Unity and VISSIM, make it possible to create simulated videos of street environments. Research teams may create customized street and environmental designs and vary the levels of pedestrians, cyclists, and vehicular traffic (Batista, Luise Berghoefer, and Friedrich 2023; Kasraian et al. 2021; Perdomo et al. 2014).

Simulated videos offer the capability to represent the specific street environment variables of interest, such as the presence of street trees, traffic volumes, street widths, crosswalk designs, etc., while also minimizing the presence of irrelevant variables (Batista, Luise Berghoefer, and Friedrich 2023; Kasraian et al. 2021; Perdomo et al. 2014). Compared with IVR, simulated videos are less expensive to develop and require less participant time. As with real-world videos, participants are constrained to the captured points of view.

Real-World Photos (11 reviewed)

Real-world photos appear to be the most common method for representing street environments (Bellizzi, Forciniti, and Mazzulla 2021; Huang et al. 2022; M. Lee et al. 2023; Navarrete-Hernandez, Vetro, and Concha 2021; Noland et al. 2017; Ramírez et al. 2021; Yang et al. 2024).

The advantage of representing street environments with photos is that photos are readily produced and available. Due to their ubiquitous supply, diverse, global environments may be presented (Navarrete-Hernandez, Vetro, and Concha 2021).

However, photos cannot capture dynamic elements of street environments, such as speeds or traffic interactions. As real-world representations, they may contain design elements irrelevant to the research subject.

Simulated Images or Drawings (5 reviewed)

Illustrated images, whether hand-drawn or computer-illustrated, are another common way of representing street environments (Adhikari 2019; P. Anciaes and Jones 2020; P. R. Anciaes and Jones 2018; Erath et al. 2015; Wu et al. 2020).

With simulated images, the researcher can manipulate design variables while eliminating the presence of irrelevant information. Unlike photographs, all aspects of the visible environment are theoretically under the researcher's control.

Yet, speed-related dynamics and interactions between travelers are not captured. The representation within each photo is limited to a single point of view.

Summary of Findings

Methodological rigor of street representation methods in transportation research surveys is underdeveloped. Few researchers publish detailed protocols, and few validate participant comprehension of the images provided. We recommend that protocols include which street environment elements should be visible for each image (i.e., street, sidewalk, buildings, cars, intersections, etc...), the location from which the image is taken, its horizontal and vertical angles, and any lighting requirements. For validation, we recommend that visual surveys include questions asking participants if they had adequate information to make confident judgments. Open-ended feedback questions on images may also prove helpful.

The table below provides a qualitative evaluation of each representation method regarding issues of concern for research. “Information Quantity” relates to the degree of information contained. “Research Control” refers to the researchers’ ability to manipulate environmental variables. “Cost and Logistics” concern the time and money involved in creating representations. “Survey Time” relates to the time survey participants spend in participation.

Table 1. Qualitative Evaluation of Street Representation Methods

	Information Quantity	Research Control	Cost and Logistics	Survey Time
In-Situ Interviews	Highest	Low	Very High	Very High
Immersive Virtual Reality	Very High	High	Very High	High
Real-World Video	High	Low	High	Moderate
Simulated Video	High	High	High	Moderate
Real-World Photo	Moderate	Low	Low	Low
Illustration or Image	Moderate	High	Moderate	Low

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SUPPLEMENTARY MATERIALS

supplementary table

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