Study Inferences and Design Guidelines

15th January 2026

Introduction

Study Overview

This report presents insights and findings from a controlled comparative study conducted with people with partial visual impairment to evaluate accessible shopping experiences across two technology platforms.
The study compared:

- Virtual Reality (VR)-based immersive shopping experience
- Mobile application–based online shopping experience

The evaluation focused on both performance outcomes and user experience, including:

- Shopping accuracy
- Task completion time
- Mental and physical demand
- Presence
- User preferences

Based on the study outcomes, this report also proposes evidence-informed design guidelines to support Walmart teams, designers, and researchers in creating more accessible and inclusive immersive shopping experiences.

Participant Details

- N = 21 (16 male, 5 female) adults with partial visual impairment (60–90% vision loss)
- Participants exhibited diverse impairment profiles, including central vision loss, peripheral vision loss, and asymmetric visual acuity
- All participants had prior experience with smartphone shopping, but limited or no prior experience with VR.

A participant testing the ShopVR prototype

A participant testing the ShopPhone prototype

Study Tasks & Data Collection Method

Task 1 – Weight task

Find and select the product that matches the specified weight.

Task 2 – Price task

Compare all products in the category and select the lowest-priced item.

Task 3 – Nutrition task

Select products based on nutritional criteria:

- For chicken breast and breakfast cereal: choose the item with the **highest protein**.
- For milk: choose the item with the **lowest fat**.

Data Collection Methods

Task completion time and error rates (logged automatically).

NASA-TLX workload questionnaire after each task

Presence and satisfaction questionnaires after all tasks were done

Semi-structured post-study interviews

Study Insights & Findings

Task Completion & Baseline Accessibility

- Across both platforms, participants successfully completed all assigned shopping tasks without external assistance
- These tasks included product selection based on constrained criteria such as weight, price, and nutritional information

***Both immersive VR and mobile application interfaces** meet baseline accessibility and usability requirements for partially visually impaired users when performing standard shopping activities*

Performance Equivalence in Accuracy

Immersive Virtual Shopping Platform

Mobile Application Interfaces

For fundamental shopping tasks, such as product identification and purchase, the immersive virtual shopping platform and mobile application interfaces demonstrate equivalent levels of accuracy.

Immersive VR does not introduce accuracy deficits for fundamental shopping tasks relative to established mobile shopping workflows

Efficiency in Task Completion

Mobile Application-Based Shopping: Optimized for list-based navigation and rapid execution.

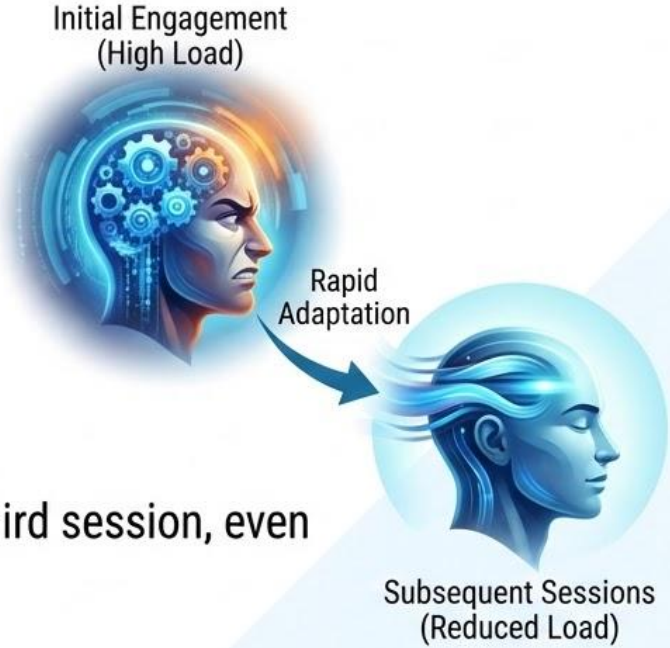
Immersive VR: Significantly higher task completion time compared to mobile-app.

For time-sensitive, goal-oriented shopping objectives (e.g., purchasing a product with predefined weight and price constraints), mobile application-based shopping enables faster task completion than immersive VR.

***Mobile platforms remain more efficient for rapid execution of well-defined shopping goals*, reflecting their optimization for list-based navigation, compact information presentation, and direct interaction patterns**

Physical & Cognitive Load among Novices

- Initial engagement with the immersive virtual shopping environment imposes a higher cognitive and physical demand, perceived effort, and frustration on novice or non-tech-savvy users, relative to mobile application-based shopping.
- These subjective parameters, however, show a marked reduction by the second usage session, with frustration levels decreasing substantially after the third session, even when performing complex shopping activities.



Immersive VR exhibits a short but measurable learning curve. User adaptation occurs quickly, suggesting that early usability costs are transient rather than structural.

Preference for Visual Inspection in Complex tasks

- In complex comparison-intensive tasks (e.g., assessing nutritional or expiry data), users exhibit a strong preference for high-fidelity visual inspection
- In this specific context, the immersive virtual shopping platform is preferred over the mobile application-based platform, positioning immersive VR as a superior modality for shopping activities requiring detailed product examination

"When shopping tasks require close visual inspection, immersive VR provides perceptual and experiential advantages over mobile interfaces"

Experiential Quality

- Participants consistently described the immersive VR shopping experience as more naturalistic, realistic, and engaging than mobile shopping
- VR was preferentially selected for non–time-critical shopping activities and was perceived as closely aligned with real-world, in-store shopping behavior

"Immersive VR offers high ecological validity and functions effectively as a digital analogue to physical retail exploration rather than as a direct substitute for mobile-based transactional shopping"

Agency & Environmental Effort

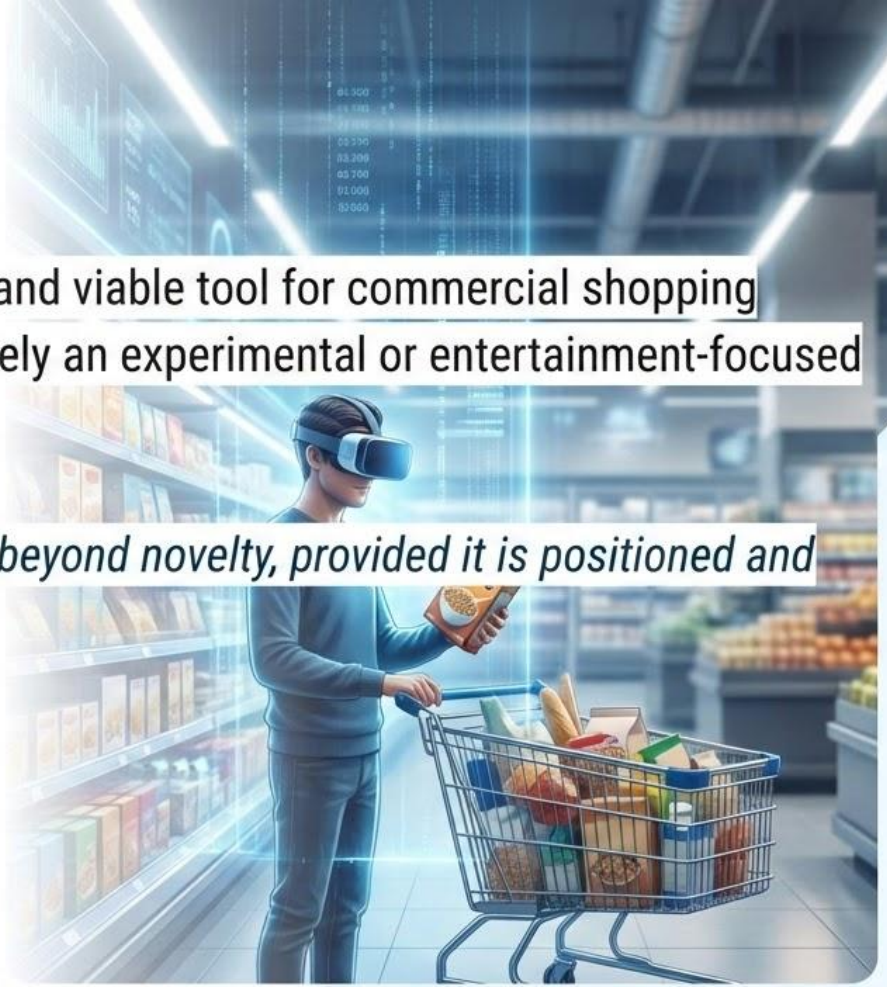
The immersive virtual shopping platform instills a robust sense of control in users and is highly enjoyable, promoting comfort and ease of interaction and navigation within the simulated environment.

> *Well-designed immersive environments can foster both experiential engagement and perceived control, countering concerns that VR interaction may feel restrictive or disorienting for visually impaired users.*

Perceived Utility

Users perceive the VR modality as a practical and viable tool for commercial shopping activities, transcending its designation as merely an experimental or entertainment-focused technology

Immersive VR holds credible commercial value beyond novelty, provided it is positioned and designed for appropriate shopping contexts



Exploration v/s Precision

Exploration & Engagement

- Immersive VR excels in exploratory, engagement-driven, and inspection-heavy shopping scenarios.

Precision & Comparison

- Effectiveness in precision-driven and comparison-heavy tasks depends on the availability of optimized information management tools

Integrating robust filtering, sorting, and comparison mechanisms is essential to improve VR performance in analytical shopping tasks

Navigation Modality Flexibility

- No single navigation strategy satisfies all users or shopping contexts
- Participants expressed varying preferences based on task urgency, familiarity with VR controls, and prior experience with interactive systems

"Immersive shopping platforms should support multiple navigation modalities—such as quick-buy flows, assisted or automated navigation, and fully manual control—allowing users to transition fluidly based on situational demands."

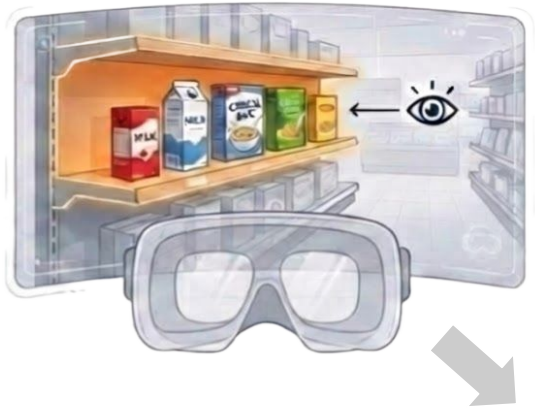
Design Guidelines

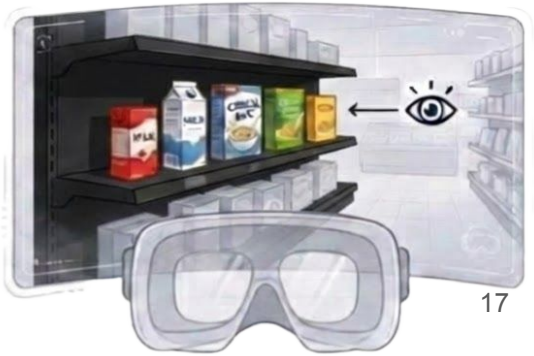
Enable Shelf-Level Background Color Adaptation While Preserving Products' Color Fidelity

Users with partial visual impairment rely strongly on original product color for rapid, first-glance identification.

Global contrast or brightness adjustments risk disrupting this color-based mental model and slow down product selection.

Adjusting shelf background color—while preserving product color and layout—improves accuracy, and selection speed





Support User-Controlled Tilting of Shelfs & Aisles to Accommodate Diverse Visual Access Strategies

Fixed shelf geometries in VR increase physical effort and reduce selection accuracy, particularly for users with central or peripheral vision impairments.

Frequent head rotation, body repositioning, and steep viewing angles slow product inspection and disrupt navigation flow.

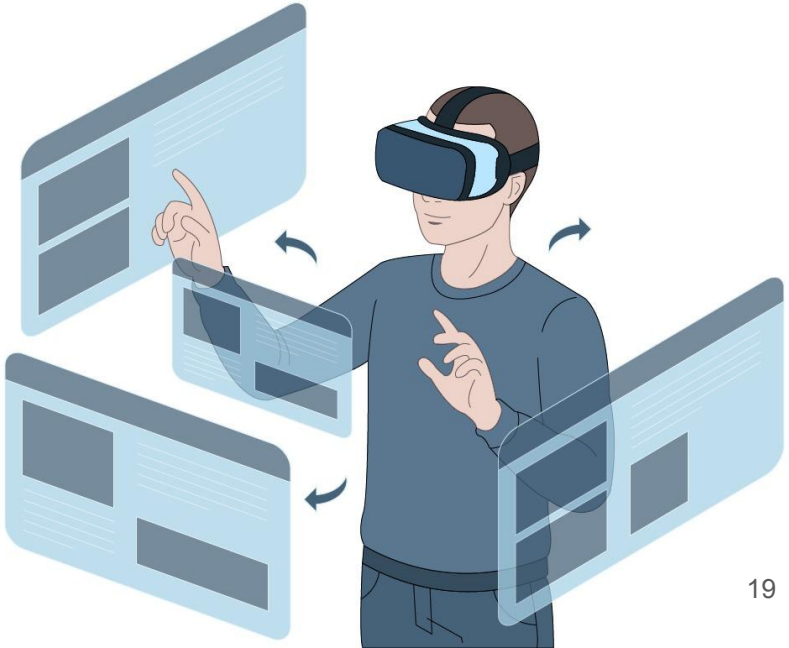
User-controlled tilting of shelves and aisles reduces physical strain and improves visibility, enabling more efficient and accessible product search

Allow User-defined Spatial Placement of User Interface Panels

Visual and interaction preferences vary widely among users with partial visual impairment, influenced by vision type (central vs. peripheral), dominant eye, and preferred viewing distance.

Fixed UI placement increases head and body movement and disrupts efficient information access.

Allowing user-defined UI panel positioning (X-Y-Z axis positioning) is recommended to provide predictable visibility, reduce effort, and supports diverse visual access strategies.



Provide Shelf-Dedicated Product Filtering and Sorting mechanism

One reason for higher errors and longer task times in VR shopping for comparison-based product select task was due to the absence of filtering and sorting tools.

Manual comparison of visually similar products on a shelf increased tiring and effortful, leading to incomplete inspection and selection errors.

Provide a shelf-level, contextual filtering and sorting (e.g., by price or weight) mechanism is recommended to enable faster, more accurate product identification

Provide Just-In-Time Summary For Each Added Item

Selection errors occur at the moment of adding visually similar products to the cart even after correctly identifying the target products, especially in comparison tasks (i.e., comparing product price, weight, etc.)

It is recommended to provide just-in-time high-level summary (preferably audio with name, weight and price) of each added item to enable verification and user confidence

Allow User-Controlled Product Attributes To Facilitate Faster Product Inspection

Displaying key product attributes (name & price) on shelves is useful for quick product view. It amplifies the usefulness if aligned with the user's current shopping intent.

VR shopping applications should display default product attributes. **It is recommended to allow users to customize which product attributes are displayed globally to support quick inspection and decision making**

Provide a Risk-Free Virtual Shopping Mode to Support Onboarding and Skill Acquisition

Initial VR shopping interactions impose higher mental and physical load and frustration, particularly for novice or low-technology-literate users, but these effects diminish rapidly with subsequent interactions

A risk-free shopping mode (e.g., trial sessions with virtual credits) enables safe exploration, accelerates skill acquisition, and reduces early cognitive and physical effort

Use Near-Realistic VR Shopping Environments, Products & Behaviours to Enhance Immersion, Presence and Naturalness

Users strongly preferred VR shopping experiences that closely resembled real-world shopping environments, reporting higher presence, enjoyment, and engagement.

Realism depends not only on interaction fidelity but also on accurate product appearance, legible packaging details, and familiar ambient cues (e.g., other shoppers, background sounds).

Provide near-realistic environments, products, and ambient behaviors to significantly enhance presence and make VR shopping feel real, intuitive and natural.

Thank You

[Project Website]

Study Media Repository

- Google Drive (videos, images, study artifacts): https://drive.google.com/drive/folders/13xvJ1hm4cnXdJGTX1CIJZ7naHANFaEAf?usp=sharing

Submitted Research Article

- Submitted manuscript (Google Drive): https://drive.google.com/file/d/1yuv40Uof10vsNlgyxFw00QcdsJRb2rJd/view?usp=sharing

Research Team

- Dr Keyur Sorathia
- Dr Nilotpal Biswas
- Smitha Venkobachar
- Jeevan A Reddy
- Swati Minz

Affiliation

Embedded Interaction Lab
Department of Design
IIT Guwahati