# A Mixed Reality eye-tracking investigation on key factors affecting food consumption habits

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## Introduction and Related Work

Traditional methods like questionnaires and food diaries, while widely used, often suffer from biases and fail to capture the complexities behind food choices [1], [2]. Advances in XR technologies, including VR, AR, and MR, have transformed food choice studies by enabling controlled experiments in realistic virtual environments [3]. These technologies, particularly when combined with eye-tracking metrics, offer more objective insights into cognitive and emotional responses to food [4]. However, comprehensive studies using MR, especially for sustainable practices, are still limited. This study addresses these gaps by integrating traditional questionnaires with MR eye-tracking, creating more realistic scenarios that enhance the understanding of demographic food preferences and sustainable practices. The adaptable MR approach allows for rapid scenario changes, providing deeper and more actionable insights into dietary behaviors.

## Methodology

This study uses eye-tracking analysis in MR to assess participant engagement by focusing on key metrics like gaze direction, duration, and fixation frequency. By refining gaze duration thresholds, the study distinguishes between brief glances and meaningful engagements. Using XR hardware and the OpenXR framework, participants interact with virtual food items in an MR environment, where their gaze behaviors are tracked. Data on gaze points, duration, and fixation locations are visualized through heatmaps, while quaternion rotation data is converted to Euler coordinates for more precise gaze direction analysis.

## Experimental Setup

The flowchart (Fig. 1) illustrates the study's methodology for examining the relationship between visual attention and dietary decision-making. Participants' food preferences are tested in a MR environment, where various food options are displayed on a table with immersive 3D visuals. This setup is tailored for eye-tracking studies, capturing detailed interactions with different food choices. Eye-tracking data is collected using Unity and the Oculus OVR Eye Gaze component, tracking gaze interactions with virtual food items. The system logs gaze fixations and processes metrics like gaze direction, duration, and fixation points. These are analyzed alongside questionnaire data to understand food choices. The findings are visualized with 3D heatmaps, highlighting areas of high visual interest, and identifying food items that attract attention. This approach combines quantitative eye-tracking data with qualitative feedback to comprehensively understand food habits and preferences.

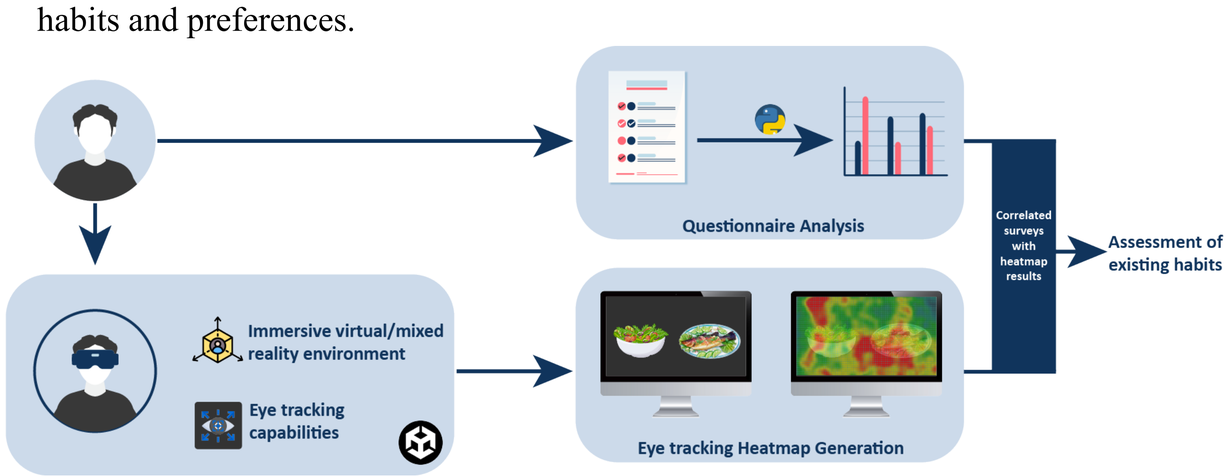


**Figure 1**. Extended Reality-Based Behavioral Analysis Flowchart: Identifying Dietary Choices through Eye-Tracking, HeatMaps and Data Analysis

## Assessment of Participants

The study surveyed 115 participants, revealing diverse food preferences and notable differences in gender, BMI, and health concerns among carnivores, vegetarians, and vegans. The carnivorous group had more males and higher obesity rates, highlighting gender and cultural influences, as well as the benefits of plant-based diets. As shown (Fig. 2), taste came out as the top factor for individuals when selecting food, followed by health, cost, convenience, and freshness.

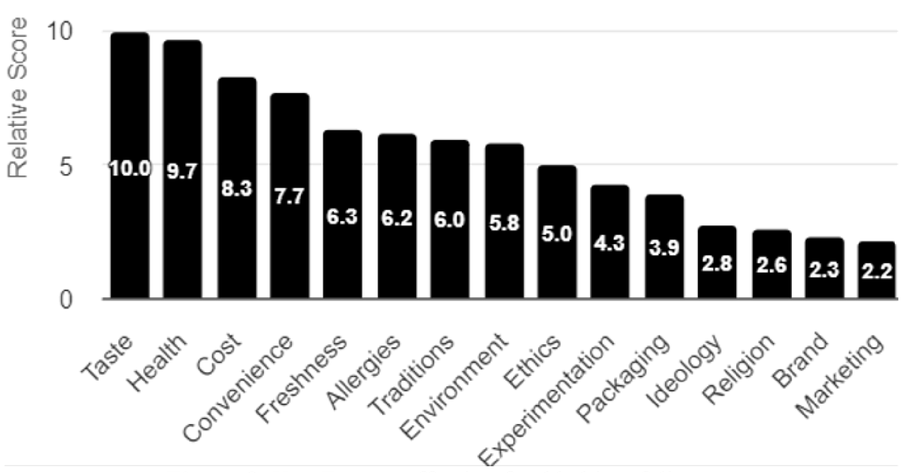


**Figure 2**. Key Factors affecting food habits of dietary groups

## Mixed Reality demonstration

Immersive Mixed Reality (MR) content was developed to analyze correlations between participants' eye-gazes and factors affecting food choices, with data storytelling elements included to enhance engagement (Fig. 3). Nutritional values of food scenarios were calculated using the NRF9.3 methodology [5], while CO2 emissions, water, and land use estimates were derived from existing studies [6]. User interactions, such as eye tracking, clicks, and gaze duration, were meticulously tracked in the MR setting.

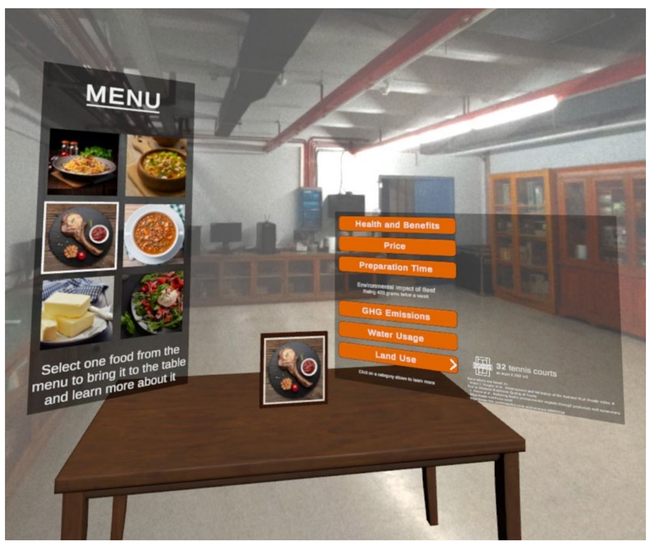


**Figure 3.** Mixed Reality Environment Setting with Data Storytelling Visuals

| Group | Scenario | Count | Total Gaze (s) | Avg (s) | Max (s) |
|---|---|---|---|---|---|
| Vegetarian | Carbonara | 2 | 0.42 | 0.21 | 0.26 |
| | Lentil Soup | 24 | 9.26 | 0.39 | 1.36 |
| | Butter | 10 | 3.72 | 0.37 | 0.88 |
| | Beef Stake | 13 | 8.06 | 0.62 | 1.44 |
| | Bean Soup | 5 | 1.62 | 0.32 | 0.52 |
| | Buratta Salad | 31 | 17.06 | 0.55 | 3.48 |
| Omnivorous | Carbonara | 39 | 26.54 | 0.68 | 4.22 |
| | Lentil Soup | 17 | 21.10 | 1.24 | 5.28 |
| | Butter | 14 | 8.76 | 0.63 | 2.14 |
| | Beef Stake | 21 | 12.68 | 0.60 | 1.78 |
| | Bean Soup | 17 | 8.76 | 0.52 | 2.24 |
| | Buratta Salad | 22 | 17.94 | 0.82 | 3.46 |
| Carnivorous | Carbonara | 29 | 14.16 | 0.48 | 1.80 |
| | Lentil Soup | 21 | 11.24 | 0.54 | 2.42 |
| | Butter | 24 | 7.60 | 0.32 | 1.02 |
| | Beef Stake | 41 | 19.28 | 0.47 | 1.76 |
| | Bean Soup | 25 | 12.24 | 0.49 | 1.20 |
| | Buratta Salad | 38 | 17.66 | 0.46 | 1.76 |

**Table 1.** Results of Number of Gazes, Total, Max, and Average Gaze Duration per Food Scenario at a sampling ratio of f = 50 Hz and minimum gaze fixation > 0.15 s

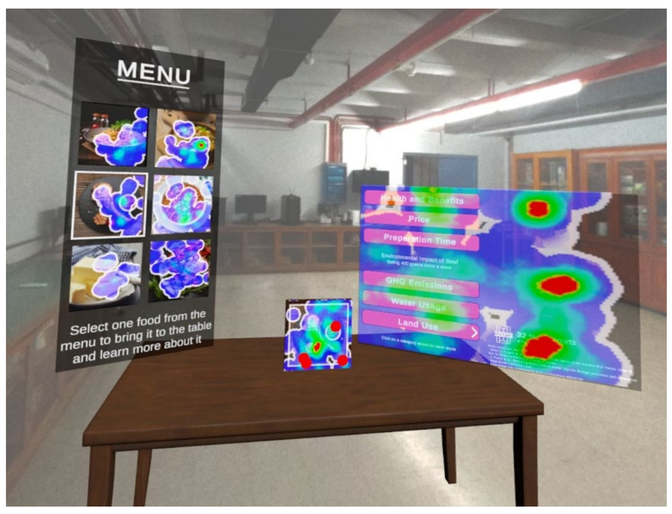


**Figure 4.** Visual attention heatmaps generated within the MR environment for omnivorous participant

Table 1 shows the engagement metrics, including clicks and gaze duration, for carnivorous, vegetarian, and omnivorous participants across various food scenarios. The omnivorous participant demonstrated higher engagement, possibly due to the complexity of their diet, while carnivorous participants focused more on meat-based scenarios, highlighting the MR environment's effectiveness in engaging users with content that aligns with their dietary preferences.

Heatmaps generated within the MR environment (Fig. 4) for an omnivorous participant highlighted areas of concentrated visual attention, offering insights into individual visual engagement with specific food scenarios. The analysis revealed that carnivorous participants engaged more with less healthy and sustainable food scenarios but also showed significant interest in health, GHG, and water use metrics, suggesting potential opportunities for educating such groups about the environmental impacts of their food choices.

## Conclusion and future studies

Aligned with common expectations, the MR environment assessment confirmed that individuals with sustainable dietary preferences spent more time engaging with images of sustainable food options, while those with carnivorous preferences focused more on meat scenarios. However, the real potential of this tool lies in its ability to reveal deeper insights into behavioral patterns. Future research will explore additional metrics such as selection patterns, physiological responses (e.g., pupil dilation and heart rate), aiming to enhance the MR tool's capability. Upcoming studies will expand on these results by developing additional MR scenarios that cover a broader range of consumer behaviors, including circular economy and climate resilience. This approach seeks to gather data on how targeted campaigns can effectively encourage a shift toward sustainable practices, ultimately contributing to societal acceptance and the success of policies promoting sustainable habits..

**References:**

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