

# Blending Physical and Augmented Dining: Exploring Social Acceptability in Mixed Reality Restaurant Experiences

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**Abstract**—Dining is a multisensory experience that is often shared with others and done in public places, e.g., restaurants. As such, it is characterized by interactions with both tablemates and the specific social norms of the venue where it occurs. The recent introduction of eXtended Reality (XR) technologies in this context, mainly through Head-Mounted Displays (HMDs), offers new opportunities for engagement while raising questions about their social appropriateness in public settings. This study explores the social acceptability of a Mixed Reality (MR) dining experience during a university-hosted public event. Twenty-four participants engaged in an immersive dining experience in an MR-based Restaurant using the Meta Quest 3 headset. Post-experience questionnaires assessed the perceived appropriateness of eating in public while wearing the device, feelings of isolation, openness to communication, comfort, enjoyment, privacy, satisfaction, willingness to recommend the experience, and willingness to use the HMD across different locations and with various audiences. Participants showed a positive attitude toward the MR dining experience and expressed openness to engaging in similar experiences across different scenarios. These findings highlight the feasibility of using MR in real-world dining contexts, opening new perspectives for the integration of immersive technologies in socially shared experiences.

**Index Terms**—dining experience, eXtended Reality, technology acceptance, social factors, immersive food technology

## I. INTRODUCTION

Dining is a multisensory and profoundly social experience, extending beyond the mere food consumption to encompass

cultural rituals and interpersonal interactions. Traditionally, dining plays a crucial role in forming and reinforcing relationships [1]. Restaurants, in particular, serve as key social hubs, facilitating connections among individuals. The introduction of eXtended Reality (XR) technologies in dining locations, which include Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR), has the potential to transform the dining landscape. Head-mounted displays (HMDs), in particular, can enrich culinary experiences by overlaying digital content into the physical environment. This integration creates hybrid environments where the traditional act of eating coexists with digital augmentation [2]. Currently, XR applications are successfully used in research and behavioural interventions to investigate consumer food choices [3], and assess dietary habits [4]–[6]. However, much less attention has been given to how social dynamics can be affected when using XR dining apps in public spaces. In this framework, social acceptability becomes particularly relevant, as it is conceived as the alignment between the use of a technology and perceived social norms, as well as the individual's own comfort and the sense of being socially observed or judged [7]. Although previous studies have explored the use of XR in dining contexts [8]–[10], very little attention has been paid to investigating aspects related to social acceptability in public scenarios.

To address this gap, the present study investigates the social acceptability of a MR-based dining simulation. We focus specifically on Mixed Reality (MR), defined as the alignment of physical and virtual environments through the synchroniza-

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tion of real-world elements with their virtual counterparts [11]. We conducted an exploratory study during a university-hosted event open to citizens investigating users' attitudes toward the social acceptability of MR-based systems, with a specific focus on the user perspective. In this study, participants consumed a snack in an MR-based Hybrid Restaurant while wearing HMDs in the presence of others. Self-reported data were collected via questionnaires assessing various dimensions of social acceptability. By examining responses within a real-world setting, the study offers insights into the challenges and potentials of integrating immersive technologies into social dining contexts.

## II. RELATED WORK

### A. Social Acceptability of XR Technologies

Social acceptability is defined as the extent to which a user's interactions with a technology align with their self-image and generate positive impressions among bystanders. This concept involves both internal user acceptance and external spectator acceptance in accordance with social norms and values [7], [12]. With the progressive integration of XR technologies into public and social life, understanding their acceptance in shared environments has gained growing relevance. Previous studies have examined the social acceptability of XR technologies across a range of contexts, including public transportation [13], [14], gaming [15], and everyday public settings involving on-body interfaces [16]. A recurring concern emerging from these works is the social disconnection created by immersive devices, which can isolate users from their surroundings. This isolation contrasts with the social nature of many public actions and may lead to discomfort for both users (performers) and those around them (bystanders) [12].

To explore these issues, many studies have relied on vignettes (e.g., images or videos) to simulate real-world situations and reach broader samples [17], while others have attempted to gain more ecological validity by comparing lab and field settings [18] or directly testing real-world interactions [15]. Previous findings consistently show that people may feel uneasy using HMDs in public, especially when others are present or the activity involves social interaction [19]. For example, social discomfort appears to stem from fear of judgment [20] and users' concern about ignoring expected social norms, such as eye contact or conversation [13], [14]. Notably, discrete and less visible interactions tend to be perceived as more socially acceptable, while full-body or highly visible gestures are typically viewed as intrusive or embarrassing [21]. However, social acceptability does not depend solely on the users' perspective. It is also crucial to consider the viewpoint of bystanders, who may experience discomfort due to external cameras on HMDs and related privacy concerns, as well as unease caused by users' gestures occurring in their immediate proximity [22], [23].

The passthrough functionality embedded in some HMDs is a promising solution to mitigate social isolation from the perspective of the wearer, as it allows users to maintain visual

contact with the physical surroundings [18], [24]. This functionality is especially relevant in social contexts like dining, where interactions with others are common. MR's ability to maintain partial real-world awareness, such as seeing one's hands, the table, and food, can reduce the discomfort of full isolation and support more natural interactions, both for users and bystanders.

### B. XR application in food-related contexts

XR in food-related contexts has been shown to enhance the affective, behavioural, and sensory dimensions of eating. This is evident in both commercial spaces, such as Le Petit Chef [25], which uses 3D projection mapping to animate dining, and experimental studies leveraging HMDs or immersive environments like CAVEs to explore food perception and behaviour [26], [27]. For instance, previous studies have demonstrated the impact of immersive technologies on hedonic food evaluations [28], user engagement [29], and increased desire and liking for food [30]. Additionally, there has been a growing interest in the potential of XR as a vehicle for promoting healthier dietary choices through multisensory and emotionally engaging interventions [4]. For example, Pennanen and colleagues [31] demonstrated that immersive environments with positively valenced contextual cues, such as a sunny day picnic scene, enhanced emotional state and encouraged a higher rating of healthy snacks compared to neutral or negatively valenced contexts. Chen and colleagues [32] showed that virtual environments featuring congruent visual properties, such as warm colours, rounded shapes, and smooth textures, significantly increased the sweetness of identical beverages, suggesting a potential role for XR in modulating taste perception through crossmodal congruency. Moreover, these results point more broadly to spatial, ambient, and architectural elements' influence on multisensory food experiences. Similarly, Long and colleagues [5] validated immersive Virtual Reality (iVR) as a proxy for real-world eating environments by demonstrating that portion size manipulations within a virtual buffet significantly influenced food selection behaviours. Further extending this line of research, Long and colleagues [33] revealed that individual variety-seeking tendencies, assessed through food choices in an iVR buffet setting, reliably predicted actual consumption patterns in corresponding real-life meals. These studies underscore the promise of XR technologies as experimental tools and practical interventions capable of shaping dietary and consumer behaviour. However, XR's long-term success and integration in everyday dietary practices will likely depend on its technological effectiveness and user-centred factors such as perceived utility, comfort, and social acceptability. As such, a deeper understanding of how individuals engage with and subjectively experience XR-based food interventions remains essential for advancing their real-world applicability and maximizing their potential impact on public health.

### III. THE MR-BASED RESTAURANT

The system, previously introduced and described in [2], leverages MR to create a hybrid environment in which virtual and physical elements are seamlessly integrated. Users are visually surrounded by a virtual restaurant setting, while passthrough technology ensures continuous visibility of nearby physical elements, such as the table, the food, and the user's hands (Figure 1), to foster natural and intuitive interactions. The MR application was developed using the Unity engine (version 6000.1.0a2), with the Meta Quest 3 as the HMD. To anchor the virtual environment to the real-world dining setup, an interactive zone was implemented using the official Meta XR All-in-One SDK (version 69.0.1). The virtual scene was constructed using a combination of pre-built assets from the ArchvizPRO Interior Vol.8 package and custom 3D models designed in Blender (version 4.2). To enhance visual quality while ensuring optimal HMD performance, baked global illumination was employed instead of real-time lighting. Spatial anchors were used for initial calibration, aligning the virtual and physical tables and allowing the system to adapt to varying table sizes and spatial layouts. The virtual environment was conceived to replicate a seaside restaurant with a panoramic view of Venice. At the center of the simulation was a dining table approximately  $70 \times 70 \times 2.5$  cm in size (Figure 1A). Throughout the experience, participants remained seated at a real table, which was continuously visible through the passthrough feature of the HMD (Figure 1B).



Fig. 1. (A) Participant dining at a physical table while wearing the HMD. (B) Participant's point of view (POV), displaying the MR interface of the Hybrid Restaurant.

### IV. MATERIALS AND METHODS

In this section, we will present the materials employed to collect data during the experiment, followed by a description of the setting and the equipment used. Finally the experimental procedure is reported.

#### A. Data collected

A post-experience questionnaire composed of three sections was administered to participants. The first section collected socio-demographic data, including age, gender, and frequency of dining out. The frequency with which participants dined alone at restaurants, as well as their prior experience with XR technologies were also assessed. The second section assessed participants' dining experience within the MR-based Hybrid Restaurant through 24 items on a 7-point Likert scale (1=

strongly disagree; 7= strongly agree), covering nine dimensions:

- Public VR, 4 items (adapted from [20]) assesses whether participants perceived eating in public while using the HMD as appropriate, uncomfortable, rude, or embarrassing.
- Public Communication, 1 item [20], evaluates the extent to which participants wished others could communicate with them while eating with the HMD.
- Isolation, 2 items [20], assesses participants' discomfort regarding feelings of isolation or separation from others while eating with the HMD, with higher scores reflecting a stronger tendency to perceive social isolation as undesirable.
- Perceived Comfort, 3 items (adapted from [34]), measures how comfortable participants felt wearing the HMD.
- Behavioural Intention, 3 items [34], evaluates the extent to which participants expressed the intention to use the HMD again.
- Perceived Enjoyment, 3 items [34], captures how pleasant participants found the activity of eating with the HMD.
- Perceived Privacy, 2 items [34], measures users' confidence that data collected by the device is handled safely.
- Satisfaction, 2 items (adapted from [35]), measures the overall satisfaction with the dining experience within the MR-based Hybrid Restaurant.
- Positive Word-of-Mouth, 4 items (adapted from [36]) evaluates participants' willingness to recommend the experience to others.

The third section evaluated participants' willingness to dine using an HMD across social contexts through 16 items adapted from Rico and collaborators [41], rated on a three-point scale (1= No, 2= I do not know, 3= Yes). Specifically, it investigates participants' willingness to use the HMD during dining experiences with different mates (i.e., alone, with a partner, with family, with friends, with colleagues, with acquaintances, with strangers) and across various locations (i.e., at home, in a cafe, in a fast-food outlet, in a canteen, in an informal restaurant, in a fine dining restaurant, at a fair, during an event, in a shopping mall).

#### B. Setting, equipment and procedure

The experiment was conducted during a university-hosted event open to the community. Participants were recruited during the event among the individuals who spontaneously approached the researcher during the exhibition. Participants who voluntarily took part in the study were first invited to read and sign an informed consent form. Then, a researcher guided each participant to a dedicated table set with tableware, a plate, and a single-serving packaged portion of Italian breadsticks. Packaged single-serving breadsticks were selected for hygiene purposes and to ensure product standardization across participants, as they are also a typical offering in Italian restaurant settings. At this point, they were instructed to eat the food portion provided within the immersive setting. Participants then wore the Meta Quest 3 HMD, immersing themselves in the

MR-based Restaurant. Throughout the experience, participants were aware of the physical presence of other individuals in the room. Upon completing the dining experience, they were invited to fill out a post-experience questionnaire administered online via the Qualtrics platform using a tablet. The entire experimental session lasted approximately 15 minutes. The local Ethics Committee approved the study.

## V. PARTICIPANTS

A total of 24 participants (19 females) were recruited to participate in this study. Their age ranged from 23 to 61 years, with a mean age of 31.04 years ( $SD= 11.5$ ). All participants reported the absence of food allergies or intolerances and no prior diagnosis of neurological or eating disorders. Regarding prior experience with XR devices, most participants ( $n= 15$ ; 62.5%) reported having previously used HMDs only during similar events or showcases. Six participants (25%) indicated this was their first experience with XR devices, while only one participant reported using HMDs either once per month (4.17%) and two more than once per month (8.33%). Concerning their dining habits, most participants reported dining out at restaurants either less than once per month ( $n= 7$ ; 29.17%) or once to twice per month ( $n= 13$ ; 54.17%). Two participants (8.33%) indicated dining out more than once per week, while another two (8.33%) reported dining out almost daily or daily. Regarding dining out alone, 66.67% of participants ( $n= 16$ ) reported never doing so, while 29.17% ( $n= 7$ ) dined alone less than once per month. Only one participant (4.17%) reported dining alone almost daily.

## VI. RESULTS

In this section, results from the questionnaires are reported. Firstly, the results concerning participants' experience and their attitudes toward the MR-based Hybrid Restaurant in a public context are presented, along with their willingness to dine with an HMD in front of different audiences and at various locations.

### A. Attitude towards the MR-based Hybrid Restaurant in a public context

For each participant, mean scores were computed across items corresponding to the subscales. Wilcoxon signed-rank tests were conducted to assess whether participants' scores significantly differed from the neutral midpoint of the scale ( $Mdn= 4$ ). Descriptive statistics and analysis results are shown in Table 1. Distributions are shown in Figure 2.

### B. Willingness to dine with HMD in different social contexts

The following section reports descriptive data from the social acceptability scale, organized by audience and location dimensions. Regarding the audience, the majority indicated they would feel comfortable using the device alone ( $n= 21$ ; 87.5%), followed by the company of friends ( $n= 19$ ; 79.2%). Moderate levels of acceptance were reported for the presence of family members and colleagues ( $n= 14$ ; 58.3%), followed by the presence of a partner or strangers ( $n= 13$ ; 54.2%).

TABLE I  
DESCRIPTIVE STATISTICS AND WILCOXON SIGNED-RANK TEST RESULTS FOR SELF-REPORT MEASURES

| Dimension              | Mean | Mdn  | SD   | Statistics V | P-value |
|------------------------|------|------|------|--------------|---------|
| Public VR              | 5.02 | 5.12 | 1.21 | 207.5        | 0.002   |
| Public Communication   | 5.71 | 6.00 | 1.46 | 253.5        | <0.001  |
| Isolation              | 4.62 | 4.50 | 1.42 | 157.5        | 0.049   |
| Perceived Comfort      | 4.96 | 4.83 | 1.13 | 223          | 0.002   |
| Behavioural Intention  | 5.33 | 5.83 | 1.24 | 220          | <0.001  |
| Perceived Enjoyment    | 5.64 | 6.00 | 0.88 | 253          | <0.001  |
| Perceived Privacy      | 5.33 | 5.50 | 0.62 | 276          | <0.001  |
| Satisfaction           | 5.44 | 5.75 | 1.01 | 286          | <0.001  |
| Positive Word-of-Mouth | 5.65 | 5.62 | 1.06 | 271.5        | <0.001  |

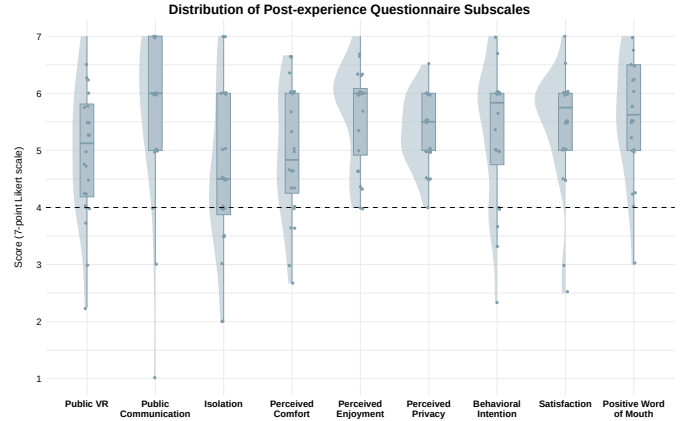


Fig. 2. Descriptive statistics and analysis results for self-report measures

The lowest level of acceptability emerged for the presence of acquaintances ( $n= 11$ ; 45.8%). Participants' willingness to use the HMD also varied by location. Events ( $n= 16$ ; 66.7%), fairs ( $n= 15$ ; 62.5%), and informal restaurants ( $n= 15$ ; 62.5%) received the highest levels of acceptance, followed by shopping malls ( $n= 14$ ; 58.3%) and the home environment ( $n= 13$ ; 54.2%). Differently, fine dining restaurants ( $n= 11$ ; 45.8%), canteens ( $n= 10$ ; 41.7%), fast food outlets ( $n= 9$ ; 37.5%), and cafés ( $n= 9$ ; 37.5%) were associated with lower acceptance rates. A breakdown of participants' responses across audience types and locations is illustrated in Figure 3.

## VII. DISCUSSION AND CONCLUSION

The present study investigated users' psychological attitudes towards an MR-based system in public dining scenarios, focusing on social acceptability. Despite the inherently social nature of dining contexts, participants reported feeling comfortable consuming food in public while wearing the HMD. However, in contrast to previous research by [19], which indicated decreased acceptability in socially interactive environments such as cafeterias, participants spontaneously expressed interest in greater interactivity. Several participants explicitly stated the desire to communicate with bystanders or to enable bystanders to see the virtual content they experienced. Interestingly, privacy concerns, identified in the literature as a primary barrier to the public adoption of wearable technologies [37], did not

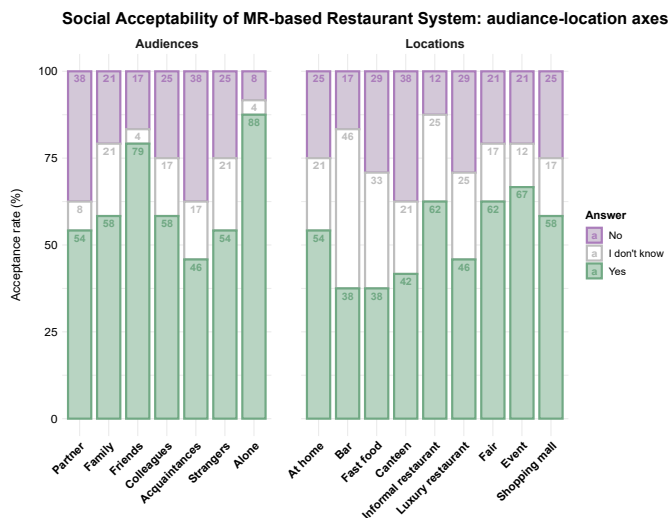


Fig. 3. Frequency of participants' willingness to use an HMD while dining, by audience and location.

emerge as problematic in this context. Participants reported high levels of comfort, enjoyment, and intention to reuse the system, consistent with prior findings that physical comfort significantly influences positive attitudes and intention to adopt wearable technologies [38]. Moreover, high overall satisfaction ratings reinforce the potential of MR applications to enhance hedonic activities such as dining. Participants also exhibited a strong willingness to recommend the experience. Furthermore, they indicated openness to dining with an HMD in various social contexts, with acceptance highest when imagining dining alone or with friends and lowest with acquaintances. This suggests that social interactions characterized by low relational intimacy may create ambiguity, reducing perceived comfort with the public use of HMDs. Perceived acceptability also varied by location type, with higher willingness observed at events, fairs, and informal dining settings compared to cafe's, canteens, and fast-food establishments, venues typically associated with rapid, utilitarian consumption. Taken together, these early indications suggest a growing potential for the integration of immersive technologies into food-related contexts, not only to enhance culinary experiences, but also as tools for research and intervention in social settings aimed at promoting dietary education to foster healthier and more sustainable food choices.

Nonetheless, limitations must be acknowledged. Although conducted in a public space, the context of a technology-focused event may have drawn individuals with a prior interest in immersive experiences, which could have contributed to a generally positive attitude toward such technologies. Additionally, the presence of other XR apps showcased at other stands, may have contributed to reducing participants' concerns. Furthermore, participants were seated at a solitary table, devoid of any other diners, with the exception of event attendees. This setting precluded the observation of social interactions that typically accompany shared meals. A relevant aspect that

was overlooked by the present study was an assessment of bystanders acceptability [12], leaving unexamined potential discomfort or privacy concerns of bystanders, when HMD-mounted cameras capture their images. This issue has already been reported with similar devices in various contexts [22], [23]. Moreover, the sample was small, limiting the generalizability of the findings. Lastly, the food item used as a prompt, while standardized for control purposes, did not resemble a complete restaurant meal, which may have affected the realism of the dining scenario. Therefore, the present experiment must be interpreted as a preliminary effort meant to be expanded and evaluated in a more ecologically valid setting, to integrate the perspectives of bystanders and also add objective measures of users' behaviours, such as eye-tracking data.

To sum up, the present study, despite preliminary, indicated a positive dining experience, broad social acceptance of the MR system in public settings, and intentions to reuse the HMD across different social scenarios. Its main contribution is drawing attention to the social dimensions of immersive dining, an aspect not yet addressed in previous research. These insights offer a valuable starting point for future studies to explore these dynamics in more structured and contextually grounded ways.

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#### CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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