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Eating together apart: Designing immersive, multisensory commensality experiences in Virtual Reality

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Figure 1: During the immersive dining sessions, participants engaged in spontaneous gestures like reaching for each other's food and initiating high-fives. Insets show the physical setup, where participants mirrored their virtual interactions while seated apart.

Abstract

Immersive technologies offer new possibilities for reimagining how people eat together across distance. In this paper, we explore the experience of shared eating in Virtual Reality (VR) through a three-phase study: (i) an initial survey in which participants (n=32) described how they would design a shared eating experience in VR; (ii) the development of a multisensory immersive commensality prototype; (iii) and evaluations with 14 participants. Our findings show that immersive eating supports playful social connection and deepens sensory engagement. Enabled by multisensory, responsive design features, participants developed new rituals and engaged in playful, norm-breaking gestures typically discouraged in conventional dining. At the same time, immersive dining introduced new behavioural tensions, including overeating driven by environmental rewards and concerns about authenticity and cultural representation. Building on these insights, we outline key opportunities and challenges for future research.

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CCS Concepts

• **Human-centered computing → Empirical studies in HCI**.

Keywords

Immersive Eating, Virtual Reality (VR), Commensality, Human Food Interaction, Multisensory Interaction, Food and Technology, Eating Behaviours

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1 Introduction

Increasingly, researchers in the field of Human-Food Interaction (HFI) are challenging this notion by exploring how technology can play a more meaningful role in our food practices. A systematic mapping study by Altarriba Bertran et al. [3] outlines the wide range of approaches within HFI that leverage technology as a tool to enhance sensory engagement and enable new forms of social connection around food. One particularly active and evolving area within this landscape is *digital or computational commensality* [48, 60]. This line of research investigates how digital tools and computational systems can facilitate shared eating experiences across distances, ultimately rethinking what it means to eat together in a technologically mediated world. This includes applications such as interactive dining interfaces [46], AI-driven conversational agents at the table [47], haptic or sensory augmentation to recreate physical presence [52, 54].

While these approaches have explored different ways to mediate commensality, immersive technologies remain largely unexamined in this context despite their potential to offer shared spatial experiences, embodied interactions, and richer sensory engagement. There are two distinct perspectives on how eating in virtual reality (VR) might unfold. On one hand, VR can serve as an opportunity to strengthen social bonds by replicating key aspects of co-presence in ways that traditional digital communication tools, such as video calls, cannot. On the other hand, there is concern that VR might distort or diminish essential elements of commensality (e.g., the sensory, cultural dimensions, etc.) inherent to traditional dining experiences. Moreover, critics argue that VR dining could lead to a detachment from real-world eating practices, making meals feel more artificial or performative [60].

Building on these contrasting perspectives of VR as both a social bridge and a potential disruptor of dining rituals, we explore how immersive technologies can support the experience of eating together without being together. For this, we developed a survey that invited participants to imagine a shared meal in an atmospheric virtual setting. Their responses emphasised a longing for immersive settings that could evoke relaxation and emotional connection through layered sensory details and evocative natural environments. They featured elements such as blooming trees, wooden textures, ambient soundscapes, and slow-paced interactions. These qualities informed the development of a co-present, multisensory dining experience VR prototype. Through recorded sessions and post-experience interviews, we examined how participants engaged with one another and their food while dining remotely. Our findings highlight a series of opportunity spaces for immersive eating technologies that extend beyond simple replication of physical meals. These spaces invite designers and researchers to explore how multisensory integration, co-created social rituals, playful improvisation, and narrative layering can enrich remote shared meals.

2 Background

In this section, we will discuss the synthesis of traditional commensality and digital eating experiences, drawing upon evidence from existing literature to elucidate their interconnectedness and implications.

2.1 Traditional commensality meets digital dinner

Food and eating are integral to our existence, supplying the vital nutrients our bodies need. Beyond its nutritional value, food is also deeply embedded in cultural traditions, offers comfort, and can serve as a meaningful way to express care, compassion, and emotional support [31]. Eating is more than sustenance; it is a culturally rich and socially embedded practice that fosters identity, belonging, and connection. In various traditions, commensality is expressed through ritual, aesthetic attentiveness, and shared meaning [57]. Communal dining has been linked to heightened positive emotions, increased everyday happiness, and overall well-being [40, 64]. Those partaking in shared meals often report greater life satisfaction compared to solitary dining [59]. However, in today's fast-paced world, many people find themselves unable to enjoy the benefits of shared meals due to various reasons such as hectic schedules, geographical separations, or changing demographics and societal norms [6, 50]. This growing trend of solitary dining has not only social but also nutritional and psychological implications. Indeed, there are studies showing that, for example, individuals who often eat alone have a lower diet quality [6, 11] and present higher odds of experiencing depressive symptoms [35, 71].

Digital commensality aims to leverage technological advancements to allow those who often eat alone to recreate the experience and advantages of shared meals, albeit virtually. This direction has seen explorations such as Mukbang platforms [5], digital agents as co-diners [25, 47], or tele-dining systems like RoomXT [32], KIZUNA [46] or CoDine [72]. While each of these approaches faces specific challenges, the overarching critique lies in the limited research addressing their ability to replicate the health and well-being benefits associated with in-person dining.

2.2 From tele-dining to immersive dining

While asynchronous tele-dining systems offer convenience, they often lack the immediacy and reciprocity that make shared meals feel socially meaningful. Prior work on systems like KIZUNA [46] and CU-Later [65] highlights this trade-off, showing that pre-recorded interactions tend to diminish the sense of togetherness. In contrast, Alhasan et al. [1] found that synchrony, shared space, and multisensory engagement are important for making digital meals feel social, highlighting the need for more embodied, real-time remote dining approaches.

While conventional technologies like video calls and co-watching platforms support social connection during meals, Virtual Reality offers a distinct mode of engagement through shared spatial environments, embodied co-presence, and ambient sensory cues (e.g., synchronised lighting or soundscapes), enhancing the feeling of "being there" [61]. These affordances may be especially meaningful for those experiencing spatial, not just social, isolation. Additionally, there is research in HFI [66, 67, 70], where tech meets food. However in several studies, users of that technology seem to want more immersive setups. For instance, in study [1] the behaviour of the participants in a digital commensality setup indicated their desire and need to share the same physical space. VR could be used for this because of its immersive features. However there are no studies looking into how people might use this space in dining, what are the opportunities and challenges of this technology. We think this space is important to study as, with development of VR hardware and software, immersive tech might play an important role in our food lives. At the same time, concerns remain that technology could disrupt the social aspects of dining. Smartphones, for example, fragment attention and reduce engagement during meals [18, 21], raising questions about whether digital tools enhance or harm shared eating experiences. As immersive technologies enter food contexts, it's essential to consider whether they support or diminish the embodied, synchronised, and multisensory elements of dining together. Importantly, the aim here is not to position VR as the only solution, but rather to consider under what conditions immersive systems might enhance or extend the possibilities of digital commensality, particularly in cases where other media fall short in producing affective resonance or sensory companionship.

2.3 Rethinking human-centric design in immersive food interaction

Recent work has started to look into identifying the essential elements that would guide the creation of human-centric immersive food experiences, anchoring the dining experience in both sensory and socio-cultural aspects. Studies like [1, 15, 19, 28, 68] serve as initial guides in this direction. For example, Gayler and co-authors conducted a complex analysis, which involved a systemic literature review followed by interviews with 18 professional chefs [28]. This work identified five key design considerations for future HFI: attending to multisensory flavour experiences, combining intrinsic and extrinsic sensory cues, linking flavour with emotion, embedding narrative, and shaping meals as unfolding, dramaturgical experiences. Additionally, a series of speculative studies [15, 29, 49] proposed participatory approaches for designing interactions with immersive technologies during meals. Despite their insights, these studies also present limitations. Specifically, the heavy reliance on storyboards and other traditional representational techniques may not adequately convey the depth and richness of immersive experiences in a mealtime context. Storyboards, by their very nature, are static and two-dimensional, often failing to capture the multisensory, dynamic, and immersive nature of VR. As Krauß et al. [37] argue, bridging the gap between imagination and lived experience requires more active forms of engagement. In response, our study adopts a Wizard of Oz approach, enabling participants to directly experience a simulated immersive dining environment. This method could allow for richer, more nuanced feedback grounded in interaction and sensory response.

3 Overall Methodology

This study followed a research-through-design approach [26], which supports iterative exploration and reflection in the development of experiential systems. This approach was well suited to our goal of understanding how immersive technologies might support remote shared meals. Our methodology was structured around three main phases: (1) a design survey exploring participants' expectations for virtual dining, (2) the development of a prototype based on the survey insights, and (3) an evaluation of the prototype through guided sessions and interviews. To guide our investigation, we asked the following research questions:

RQ1: How do people eat, interact, and experience food together in immersive virtual environments?

RQ2: What opportunities and challenges emerge when reimagining shared eating experiences through immersive technologies?

Phase 1: Exploratory survey. In this paper, we conducted a brief survey with 32 participants to explore how they imagine remote shared meals in immersive environments. Exploratory surveys are a common early-stage method for eliciting user insights, preferences, and imagined scenarios to inform concept development [33, 56]. Our survey invited them to describe sensory elements, spatial settings, and emotional tones they associated with meaningful virtual dining experiences. This helped surface key themes such as calm, ritual, nature, and sensory attentiveness, which directly informed the design of the prototype.

Phase 2: Prototype development. Based on the survey responses, we developed an immersive prototype simulating a multisensory dining experience in VR. The prototype aimed to evoke co-presence and and shared rituals, without relying on fully implemented technical systems. Participants interacted with the system through a guided, immersive scenario that incorporated ambient visuals, avatar presence, audio cues, and physical food components.

Phase 3: Prototype evaluation. We invited 14 participants to engage with the prototype and reflect on their experience through post-session interviews. This allowed us to investigate how people interpreted and responded to immersive commensality, and to identify which design elements most supported feelings of togetherness and sensory engagement.

4 Phase 1: Exploratory survey and design features

Building on early-stage design methods [33, 56], we used an exploratory survey as an imaginative probe into participants' expectations and values around virtual commensality.

4.1 Participants and procedure

Thirty-two participants (we will refer to them as PDS1-PDS32) were recruited via social media platforms (Instagram and Facebook). All provided informed consent before participating. The survey was delivered online using Google Forms and designed to gather open-ended, qualitative input for early-stage design exploration. No demographic data were collected, as the focus was on breadth of imaginative responses rather than participant profiling. The survey, consisting of three questions, was structured to probe participants' expectations for virtual dining in a calm, sensory-rich, and emotionally engaging environment. It asked them to envision the ambiance, interactions, and narrative elements they would find meaningful in a virtual shared meal. Questions also explored how such experiences might address everyday eating challenges or support new habits, and how they could foster social connection or emotional resonance (e.g., *Transport yourself to a dining experience in virtual reality. Describe in detail the surroundings, ambiance, and your dining sensations; What issues do you hope to address through this virtual reality eating experience? Are there specific features that could help you improve your eating habits?*). Together, these prompts aimed to surface experiential qualities that could inform the development of an immersive prototype.

4.2 Data analysis

We analysed the survey responses using an inductive, semantic thematic analysis following Braun and Clarke [8]. Four researchers and two developers participated, with the lead coordinating the process. To minimise bias, developers were not the sole analysts; the coding team brought diverse perspectives. After familiarisation, open coding identified experiential elements such as ambient sound, sensory modulation, storytelling, and co-dining rituals. Specific codes emerged (e.g., "*ambient audio layering,*" "*ingredient storytelling,*" "*eating pace modulation,*" and "*synchronous co-dining*"), reflecting tangible design features and experiential goals like focus, curiosity, and mindfulness. These codes were refined through iterative discussions and clustered into overarching themes based on participants' descriptions. Collaborative meetings ensured alignment and internal triangulation. Themes were developed inductively with supporting data extracts, including cases that diverged from the dominant patterns. Peer discussions further enriched the analysis. We collaborated closely with two developers to translate affective feedback into features like simulating a "*slow meal tempo*" or triggering narrative elements through dish interaction. This informed a user-grounded feature specification for the prototype.

4.3 Translating design directions into features

Based on codes derived through the thematic analysis of the survey responses, we identified five themes, which we present as key experiential features that participants consistently associated with meaningful virtual dining. These themes were conceptually rich and also frequently mentioned across the dataset, reinforcing their relevance for prototype development. Below, we present each design feature (DF) with supporting participant quotes and a description of how it was operationalised in the prototype.

4.3.1 DF1: Multisensory cues. **Sound** emerged as a particularly rich modality. Seven participants envisioned natural outdoor sounds, including insects and water, while six specifically mentioned the relaxing quality of sound. For example, "*I would like to hear the cricket sounds*" (PDS1) and "*I would love to listen to the spring water*" (PDS3). In parallel, **visual** elements like soft lighting and detailed scenery were seen as essential to mood-setting: "*The decor is a mix between modern and traditional*" (PDS7). **Scent** was another important feature, particularly references to outdoor aromas. Nine participants expressed a desire to smell floral or garden scents, including "*I want to be able to smell the cherry blossom and the garden*" (PDS25). **Tactile** and **environmental cues** such as wind and texture were also valued. Six participants described temperature-related sensations, especially breezes, as key to enhancing realism and immersion: "*I would like to be able to feel the leaves coming onto my face with the wind*" (PDS14); "*It's cold and snowing outside, you sit in a warm room made of cedar wood*" (PDS8). Three others mentioned the texture of grass underfoot, including: "*I would love the experience of sitting on the grass and feeling its texture beneath me*" (PDS9).

These observations support prior work in HCI and VR which highlights the role of layered multisensory environments in enhancing user presence and supporting emotional regulation [10, 27, 69]. In our study, participants explicitly linked these features with their capacity to support mindfulness and slow, intentional eating. For example, one noted: "*It's like dining in a dark restaurant; you focus on and appreciate the senses more*" (PDS7). In particular, studies in HCI and VR have found that combining sensory modalities can anchor users more fully in the virtual moment, enhancing mindfulness and emotional grounding [69, 75]. Taken together, these findings highlight the importance of layered sensory cues as aesthetic enhancements and as experiential foundations for immersive, emotionally resonant commensality.

4.3.2 DF2: Nature-inspired environments. A notable and recurring pattern in participants' responses was the preference for **outdoor**, **nature-inspired environments** as the setting for immersive dining. While VR often invites associations with fantasy, futurism, or abstract spaces, participants in this study repeatedly described a desire for calm, sensory-rich natural settings – especially gardens, forests, water springs, flowers or seasonal scenes: "*I would love the experience of sitting on the grass and feeling its texture beneath me*" (PDS9); "Eating while sitting near a nice view or some nature, like a garden" (PDS6); "*An outdoor area at the top of a mountain that can be reached through a wooden bridge*" (PDS30). These seemed to be emotionally meaningful contexts that supported a sense of tranquility, groundedness, and slow interaction. The emphasis on gardens, grass, and traditional outdoor elements reflected a longing for stillness and natural symbolism within the digital space. Such spaces offered a contrast to everyday overstimulation and urban or screen-based environments. This finding echoes broader work in HCI and VR that emphasises the benefits of biophilic and restorative design. Prior studies have shown that nature-based virtual environments can support emotional regulation, presence, and digital wellbeing [58, 63]. Through our survey, participants' preferences suggest that naturalistic VR settings may be particularly effective for social technologies, especially those involving food.

4.3.3 DF3: Synchronisation. Across responses, participants emphasised that the feeling of being together while apart hinged on one key condition: **synchronisation**. More than simply occupying a shared virtual space, participants wanted to **eat the same food** at the same time, **feel the same environmental cues**, and **react in coordinated rhythms**, as one would in a physical, co-present meal. Eight participants mentioned the importance of eating the same dish, linking it to a ritual of alignment and openness: "*Eating the same dish helps trust and encourages to share personal stories, which is why it is commonly served at business meetings*" (PDS7). Sixteen others stressed the emotional power of inhabiting the same environment, not just visually, but in terms of actions and timing, which was seen as supporting attunement and mutual awareness: "*I think people nowadays don't just crave food; they crave emotions. When I eat with someone, I want to share the same experience and feel a sense of unity, both of us being in the same environment and experiencing the moment together*" (PDS22); "*It's great to match eating paces with someone to create a more synchronized dining experience... I often suggest [my brother] slow down a bit, which could also help me eat a bit faster, as I'm usually a slow eater*" (PDS5). Others went further, imagining richer interpersonal interactions such as feeding each other or tasting each other's meals: "*I want to interact equally with the other person, like we can share our food and feed each other. I can try their dish too...*" (PDS1). These desires align with prior research in HCI suggesting that synchronous interactions, whether through environment, pacing, gestures, or sensory events, help establish trust and emotional resonance in digital spaces [4, 62].

4.3.4 DF4: Food literacy. A prominent theme across participants' responses was the desire for accessible and contextual **food information**. Many expressed frustration with real-world nutritional labels, describing them as easy to ignore or too abstract to influence actual behaviour. In contrast, they saw the immersive immediacy of VR as an opportunity to turn food data into something personally engaging, actionable, and socially shared: "*I need to have calorie and food data readily available because I dislike reading labels and often overlook the consequences. If this information is more prominently displayed, I might take it more seriously — or if I can have direct consequences in the virtual world like losing coins or features or items*" (PDS5); "*With VR, it feels like it's right there on my face NOW! This creates a sense of urgency... making me feel more obligated to follow it*" (PDS18). These reflections support recent HCI work on immersive scaffolding, where feedback is integrated directly into the user's perceptual field and tied to meaningful action [73]. By making feedback dynamic, immediate, and socially visible, immersive systems can prompt users to reflect on and modify their eating habits more effectively than static content. Participants also expressed a desire for learning beyond nutrition, including recipes, ingredients, and especially cultural stories tied to food: "*I would like to know more about the food's background, recipe, and ingredients*" (PDS17); "*I really want to learn about the history of the dish and its cultural importance*" (PDS3). This aligns with previous HCI research that explores how interactive storytelling and cultural framing can enrich food appreciation and foster reflection [28, 30]. Together, these insights suggest that immersive dining systems can function as social tools and platforms for nutritional awareness and cultural education.

4.3.5 DF5: Magic, surprise, and play. Alongside their interest in nature-based environments, many participants envisioned dining settings enhanced by subtle magical elements. Eighteen participants described wanting dining experiences that were more memorable and engaging by integrating magic or narrative variation, suggesting that fantasy could deepen reflection and social bonding: "*Dining in a fantasy world would make the experience more memorable and captivating*" (PDS3); "*Dining with someone in a fantasy world would help me connect with them — there would be so much to talk about*" (PDS11). One participant described wanting to eat in a landscape "*like Charlie and the Chocolate Factory*" (PDS10), while another longed for a fantastical anime-style garden (PDS5). Several also emphasised the importance of surprise as a counterpoint to routine dining: "*The unpredictability of what appears next in the environment could add curiosity and surprise. It can help bonding and mindful eating*" (PDS19). These perspectives align with HCI work that emphasises the value of dynamic, emotionally evocative design in immersive experiences [28, 51]. In this context, gentle narrative shifts and symbolic transformations can serve as tools for deepening co-presence and supporting the act of commensality.

5 Phase 2: Prototype development

5.1 Prototype features

To bring the five design features into practice, we developed a series of interlinked prototype features that collectively shaped the immersive dining experience. Table 1 summarises how each prototype element maps onto the five design features described earlier.

The experience was anchored in a seasonal garden setting – a calm, nature-inspired environment featuring grass, cherry blossoms, and a dreamlike ambient glow. Participants were in this space in real time, reinforcing co-presence through shared environmental cues. A layer of multisensory feedback, including spatial audio (e.g., crickets, flowing water), ground texture, simulated wind, and floral scent diffusion, complemented the setting. These sensory elements were aligned to match the feeling of being outdoors and support mindful, slow eating. To further tie food to place, participants consumed matcha-honey bites, chosen to reflect the greenery and calm of the garden and visually represented in the virtual scene. Occasional ambient animal interactions, such as small rabbits moving through the environment, encouraged light, playful engagement without detracting from the meal. Several features were designed to foster synchronisation and a sense of shared progression between participants. A system of partner-triggered ambient cues meant that when one person took a bite, a subtle transformation: a glowing sky, a waterfall, or the appearance of distant mountains became visible only to their partner (see Figure 2). To regain a shared view, the partner would then take a bite themselves, triggering the next step in the sequence. This mechanism created a rhythm of mutual awareness and interaction, where eating became a form of turn-taking. These cumulative environmental changes introduced

Table 1: Mapping of prototype features to design focuses (DF1: Multisensory cues, DF2: Nature-inspired environments, DF3: Synchronisation, DF4: Food literacy, DF5: Magic and surprise).

Prototype Feature	DF1	DF2	DF3	DF4	DF5
Multisensory feedback (wind, scent, ground texture, natural sounds)	X	X			
Seasonal garden setting (blossoms, grass, lighting)	X	X			
Edible extension of the environment (matcha-honey bites)	X	X		X	
Ambient animal interaction (rabbits)		X			X
Partner-triggered ambient cues			X		
Synchronised sensory stimulation	X	X	X		
Nutritional overlays				X	
Subtle magical transitions (sky changes, glowing blossoms)	X	X			X
Fantastical cues grounded in nature (e.g., oversized petals)	X	X			X
Surprise-activated details (e.g., rabbit appears after a bite)	X	X			X

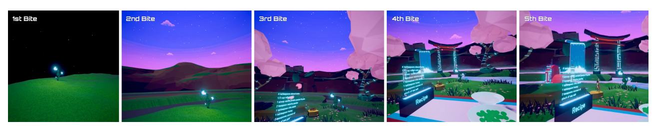

Figure 2: The environment comes to life with each bite: 1st bite (grass and plants); 2nd bite (sky and mountains); 3rd bite (cherry blossom tree with scent and breeze); 4th bite (waterfall and bridge); 5th bite (a bunny).

a sense of unfolding narrative and magic, making the world feel responsive and alive. In parallel, synchronised sensory events, such as coordinated shifts in sound, wind, or scent, helped align the experience temporally and emotionally. To support reflection and food literacy, the prototype also included nutritional overlays displaying contextual information about calorie content and ingredients, designed to remain unobtrusive within the immersive space.

5.2 Prototype implementation

To operationalise the five design focuses, we developed a functional prototype combining partially automated interactions with Wizard of Oz style sensory triggers. While virtual elements such as bite recognition, environmental changes, and synchronised avatars were system-driven, physical sensory elements (e.g., scent, wind) were manually activated by the researcher to maintain realism and responsiveness. Figure 3 illustrates the full experimental setup used during the sessions.

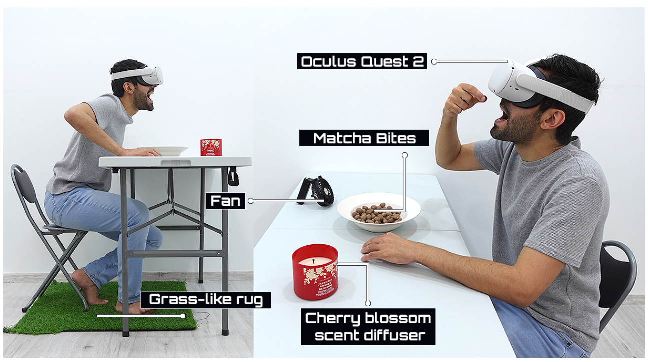

Figure 3: The experimental environment, showcasing the integration of VR equipment, eating setting, participant seating, and multisensory elements.

5.2.1 Hardware configuration. The system used two Oculus Quest 2 HMDs, allowing participants to share the same virtual environment. Hand tracking detected bite gestures that triggered virtual transformations. Each participant sat at a small dining table with real food and no controllers, encouraging natural interaction. Multisensory cues were delivered via low-cost devices: a fan for wind, a cherry blossom diffuser for scent, and a grass-textured rug for tactile feedback. These were manually activated in sync with digital triggers.

5.2.2 Software and virtual environment. The immersive experience was developed using Unity3D[1]. Multiplayer synchronisation was managed via Photon Fusion[2], allowing real-time shared actions, environment changes, and coordinated avatar movement. Meta's Avatar SDK[3] was used for personalised, expressive character representations. The environment was modelled in Blender3D[4] and depicted a stylised seasonal garden. Key assets included cherry blossom trees, soft natural terrain, and ambient animated elements (e.g., sky gradients, waterfalls, floating petals). Spatialised audio was used to create a rich acoustic atmosphere with crickets, water, and distant wind.

5.2.3 Physical space setup. To enhance immersion and align physical and digital realities, the real-world setting mirrored the VR environment. Participants sat at identical tables with a plate of matcha-honey bites. These snacks were selected to reflect the theme of natural ritual and were also visually replicated in VR. The surrounding space was enhanced with a grass-like rug to simulate outdoor ground texture, a fan for wind, and a scent diffuser with a floral note to evoke garden ambience. Two researchers (one per participant) triggered these effects manually in response to system-detected bite gestures, using a side monitor showing real-time logs. The prototype thus allowed for convincing sensory augmentation without full sensory automation, making it lightweight and suitable for iterative evaluation in co-located experimental settings.

6 Phase 3: Prototype evaluation

To evaluate how the prototype supported shared dining in immersive settings, we conducted paired VR eating sessions to explore users' social engagement, sensory perception, and reflections on food practices.

6.1 Participants

We conducted the evaluation over seven sessions involving 14 participants (P1-P14, grouped in seven pairs), recruited via targeted social media advertisements on platforms such as Instagram and Facebook. These participants were independently recruited from Phase 1 to avoid overlap and minimise familiarity bias, ensuring fresh perspectives on the prototype. Each was paired with an unfamiliar partner to encourage authentic and unscripted social interactions. Participants were selected to represent a range of cultural backgrounds including the Middle East 50%, Asia 21.4%, Europe 14.3%, North America 7.1%, and South America 7.1%, genders (6 females and 8 males),. The group included individuals from professional backgrounds, such as digital artists, engineers, chefs, travel influencers, and athletes. Ages ranged from 18 to 44, and participants varied in their familiarity and levels of experience with VR, fostering a broad perspective on immersive dining with VR: 71.4% had used VR only once or twice before, 14.3% used it weekly, and 14.3% had never used it prior to this study. The sample also included participants with differing physical abilities, allowing for reflections on how immersive dining might serve diverse needs and contexts.

6.2 Procedure

Each session involved a pair of participants who were unfamiliar with one another. Recruitment was conducted through social media advertisements on Instagram and Facebook, and the selected participants were placed in separate rooms equipped with identical physical setups, as described in Figure 3. Upon arrival, participants were instructed to sit on a designated chair, remove their shoes, and place their feet on the grass-like rug. They received verbal guidance on how to use the system, followed by a short hands-on tutorial that allowed them to become comfortable with the hand-tracking interactions and virtual interface. Once ready, each participant entered the virtual environment via a headset, where they could see and

[1]https://unity.com/
[2]https://www.photonengine.com/fusion/
[3]https://developer.oculus.com/documentation/unity/meta-avatars-overview/
[4]https://www.blender.org/

interact with their dining partner in real time. The plate of matcha-honey bites was placed in front of each participant, and they were asked to align the physical plate with its virtual counterpart inside the headset. No further instructions were provided regarding how to behave or interact during the session. Participants were encouraged to explore and engage freely with the experience and their dining partner. The immersive session lasted approximately 15–20 minutes, after which participants were notified of its conclusion.

6.3 Data collection

To build an understanding of participants' experiences, we employed a mixed-methods approach combining interviews and audiovisual documentation. This allowed us to capture both in-the-moment responses and longer-term reflections.

Qualitative interviews: After each session, participants took part in semi-structured interviews lasting 30–50 minutes, conducted by a researcher. Open-ended prompts encouraged reflection on the immersive dining experience, social connection, and prototype features. Example questions included: *"How did your experience of eating in VR compare to eating in real life?"* and *"Which features stood out or enhanced your enjoyment of the experience?"* Interviews were audio-recorded and transcribed verbatim for analysis.

Audiovisual documentation: Each session was documented through video and audio recordings capturing participants' physical behaviours and verbal expressions both inside and outside of VR. This dual-environment documentation allowed us to annotate social cues, interaction patterns, and moments of surprise or disengagement.

6.4 Data analysis

Data from all our sources was analysed through an reflexive thematic analysis process [9]. The research team, comprising three researchers, first immersed themselves in the dataset through multiple rounds of reading and preliminary note-taking. Early observations captured initial impressions such as: *"Participants engage their senses," "Technology encourages ritual-like behaviours"*, etc. An iterative coding process followed, in which data was labelled using open coding. This allowed emergent themes to surface organically, grounded in participants' language and experiences. Codes were generated to reflect both surface meanings (semantic) and underlying motivations (latent), and were refined through collaborative review sessions. The lead researcher coordinated the analysis with two other researchers who independently coded the data before collaboratively integrating their findings. The entire data analysis process took four weeks. Structured group sessions were held throughout this period to review and align codes with the research questions, supported by transparent documentation. To enhance credibility and reduce confirmation bias, we used internal triangulation by incorporating the perspectives of the research team and cross-checking interpretations. All sessions were transcribed and analysed by the research team. Prototype developers were excluded from data analysis, and two external experts validated the findings. Participants were assured of confidentiality, and open-ended questions helped minimize self-reporting and social desirability biases. Subsequently, related codes were then grouped into higher-level themes, iteratively compared for coherence and distinction. The final themes captured five behavioural patterns in digitally mediated commensality.

7 Results

7.1 Behavioural patterns during immersive commensal experiences

These patterns reveal how participants interacted with the system, one another, and the food in the immersive setting.

7.1.1 How participants shaped the sessions. Although the immersive eating sessions followed no fixed script or interaction rules, participants quickly adapted to the unfamiliar setting through recognisable behavioural phases. From entering the space to concluding their final bites, participants shaped the sessions into co-created experiences. This progression revealed a layered arc, starting with **exploration**, moving into **synchronised action**, and often ending with **playful**, social gestures.

Upon entering the virtual garden environment, most participants began with **visual and verbal exploration**. They looked around, commented on the scenery, and tested their gestures and movements: "*Are we in space? Or what's the location?*" (P5). Several duos used the early minutes to establish social rapport, including four groups who initiated a round of rock-paper-scissors as an icebreaker. Others engaged in sensory guessing games, trying to identify the food based on scent or texture, often aloud and collaboratively: "*What do you think's on our plate?*" (P7). As the environment began to respond to their eating actions, participants increasingly **sought synchrony with each other**. Some explicitly asked to "*eat at the same time,*" while others began timing their bites to unlock environmental effects in tandem, establishing rhythms of coordination. This form of synchrony was spontaneous, often playful, and became a subtle form of bonding. By the later phases of the experience, participants' comfort and familiarity grew into **improvisation and experimentation**. They began testing the affordances of the virtual space – from handshakes and high-fives to joking gestures like avatar slaps or pretending to steal each other's food (Figure 1). These playful disruptions, which could be considered impossible or inappropriate in real-world dining, emerged as a central dynamic enabled by the anonymity and flexibility of the medium.

Just as mobile phones have introduced new dining behaviours, like photographing meals or sharing food moments online [2, 74], VR invites new forms of social play around eating. In our sessions, participants tested the limits of the environment through improvised gestures (e.g., avatar handshakes, slaps, or food-stealing). These were not performed for documentation or display, but emerged spontaneously within the moment. This suggests that immersive dining can support new social scripts grounded in co-presence and interaction, rather than external presentation.

7.1.2 Multisensory cues functioned as anchors for connection. Sensory cues served three key roles in the experience: (i) anchoring participants' attention, (ii) facilitating social connection, and (iii) deepening reflection on the food itself.

Participants frequently described how sensory cues, like the texture of the grass underfoot, the sound of flowing water, or the breeze from the fan, **helped them feel more grounded and present**.

These details encouraged focus and mindfulness within the scene. One participant noted: "*The wind and the sounds made it feel like I was actually sitting outside. It made me slow down and just enjoy it more" (P3).* Another described how the combined sensory effects heightened presence: *"The sweetness of the matcha and the vibrant and bright colours of the surroundings gave me a sense of positivity. While indulging the matcha I loved the sensation of the grass below my feet. I don't know but it kinda gave the matcha an earthy and fresh taste"* (P7). Beyond sensory grounding, some participants described a deeper emotional impact. P6, a wheelchair user, highlighted how the combination of sensory immersion and social presence blurred physical barriers: *"Being on that virtual bench, sharing the same food, I momentarily forgot my wheelchair. [..] I cared only about feeling free and similar to the other person"* (P6).

Participants' connection to each other was mediated by sharing a layered multisensory world. It was the combination of taste, smell, touch, sound, and visuals, all experienced simultaneously at times, that created a strong sense of co-presence. As one participant reflected, *"When we started to taste the real food, I felt there was something real in common between us. And that made me connect with her"* (P4). Another noted how eating together became a powerful bridge across physical separation: *"It was truly mind-blowing to experience this shared connection of a common and real taste within our bodies despite being physically separated"* (P2). Each sensory modality did not act in isolation, but reinforced the others, making the experience feel more embodied and socially meaningful. The shared sensory landscape amplified feelings of trust and openness: *"I also think the common senses between me and the other person brought us more together, made me trust her more and be open"* (P8). The act of users feeding each other (four out of the seven pairs) further illustrated this bond (Figure 1). This gesture, often reserved for more intimate settings, underscores the level of trust and connection the experience facilitated.

Multisensory immersion also shaped how **participants engaged with the food itself**. The environment seemed to amplify participants' sensory attention to taste, texture, and even the symbolic meaning of what they were consuming. Eating in VR shifted from a functional act to a moment of deeper reflection. Participants described how the integration of environmental cues — like the feel of grass underfoot or the sight of cherry blossoms — subtly changed how they perceived and appreciated the food. As one participant shared, *"What remains clear in my memory are the flavours and textures on my plate. The sweetness of the matcha and the vibrant and bright colours of the surroundings gave me a sense of positivity."* (P7). The multisensory setting seemed to encourage a slowing down and heightened awareness, leading participants to attend more closely to the taste and meaning of the food. One participant reflected *"I engaged my smell, I've engaged light touch, I've engaged my taste buds. So I think as long as it is something you feel in real life, it potentially could add that value. I think food was a really good one because it captured multiple of those physical senses at the same time"* (P8).

7.1.3 Environmental rewards overpowered nutritional awareness. In our study, we introduced real-time calorie and ingredient information alongside the dishes to observe how participants would react to nutritional data during an immersive eating experience, and whether it would influence their eating behaviour. Participants' behaviour showed that instead of focusing on calorie information, many were more motivated by the changes in the environment that happened when they ate. Although participants initially noticed the calorie overlays, 13 out of 14 ultimately overlooked them during the immersive experience. Their focus shifted toward the unfolding scenery and multisensory changes linked to each bite. As one participant admitted, *"I'm full but I'll eat to get the environment colourful again"* (P3). This finding reflects previous work showing that calorie labelling alone has limited impact on real-time eating behaviour, particularly when competing with strong experiential cues [7].

The immersive system's use of environmental rewards, such as unlocking new landscape elements or animations after a bite, was a far stronger behavioural driver than the informational data provided. Several participants described feeling "*motivated*" or "*curious*" to keep eating, even after reaching satiety, in order to discover what would happen next. In one case, a participant reflected: *"I think every bite that we eat we will explore more about it"* (P8). Another commented during the session: *"I'm full but I'm gonna have more just to see what's gonna happen"* (P12). Interestingly, while most ignored the calorie information during the experience, some found it valuable when aligned with their personal goals. One participant who was an athlete noted: *"I liked the calories because it is something that is important to me to know the amount"* (P5), suggesting that food datification may serve specific user groups but not the broader immersive population by default. These observations highlight a design tension: simply layering data onto eating experiences may be insufficient, especially in sensory-rich environments. Instead, participants suggested that multisensory or narrative cues might more effectively promote mindful eating. For example, P4 proposed linking environmental qualities to food choices: *"Maybe if I don't finish my food something happens, like bad smells or spirits. If I choose unhealthy food, it could change the environment around me"*.

7.1.4 Play as a social and exploratory practice. Participants used play both as entertainment and as a way to navigate social unfamiliarity and test interpersonal boundaries. In the early moments of the session, playful gestures like rock-paper-scissors acted as spontaneous icebreakers, helping participants feel at ease. As one participant laughed: *"We didn't even know each other's names, but after the first silly game, it felt much lighter" (P7).*

As the experience progressed, playfulness evolved into more improvised forms of social experimentation. Participants engaged in light-hearted mischief, such as trying to "*steal*" food from each other's plates (Figure 1) or jokingly slapping their avatars. These behaviours, while playful, signalled a lowering of inhibitions and the building of mutual trust. As P2 reflected: *"I forgot about real life and just thought, let's do something silly and see what happens."* Importantly, many of these playful behaviours – like stealing bites or initiating physical gestures during meals – would typically be considered inappropriate or rude in conventional dining contexts. In VR, however, the usual social constraints around eating were loosened. The immersive environment offered a safe space for boundary-testing and social improvisation, supporting prior findings that VR can encourage norm-breaking and creative expression [24, 42].

Notably, participants did not simply interact with the environment as designed. They invented their own playful behaviours, expanding beyond the system's intended affordances. Even within a setting centred on eating – a highly structured social activity – participants actively sought out opportunities for interaction and co-created new forms of engagement. This highlights VR's unique capacity to foster emergent, self-directed social play, suggesting that users may instinctively shape new dynamics when freed from traditional expectations.

7.1.5 How did participants see the future of immersive eating? Throughout the study, participants reflected not only on their immediate experiences but also on how immersive eating technologies might extend into their future lives. Many envisioned scenarios where geographical separation would no longer prevent meaningful shared meals. As P5 imagined: *"Imagine having a dinner date with your family in another country – but it feels like you're actually sitting together under the cherry blossoms."* Others framed immersive eating as a gateway for education and cultural exploration. Instead of simply reading about distant cuisines or traditions, participants envisioned eating as a mode of embodied learning. As P4 put it: *"It would be cool to 'travel' to another country through food — like a real experience, not just reading about it."*

Several participants also saw therapeutic and emotional potential, suggesting that immersive meals could support social reconnection, sensory rehabilitation, or mindful eating. For instance, P6, a wheelchair user, reflected: *"It made me feel free again. I think it could help others too — to eat with someone, without barriers."* These visions highlight the possibility of using immersive commensality not just for entertainment, but for strengthening care and inclusion.

At the same time, participants were cautious. Some raised concerns about whether the sensory richness could encourage overconsumption or lead to sensory fatigue, with one participant admitting: *"I was full but I kept eating because I wanted to see what would happen next"* (P12). Others questioned whether replacing physical gatherings with virtual ones might weaken existing social bonds over time. These reflections suggest that while immersive eating offers powerful new modes of connection, exploration, and wellbeing, it must be designed carefully — not simply as a substitute for real-world experiences, but as a complementary, meaningful extension of them.

8 Discussion

Our study suggests that immersive technologies go beyond replicating physical meals by reshaping the contextual, social, sensory, and emotional aspects of shared eating. Based on participants' behaviours and reflections, we outline four opportunity spaces (OS) for future design and highlight key tensions to support connection and wellbeing.

8.1 OS#1: How should eating enter virtual spaces?

As immersive technologies permeate daily life, a key question arises: should eating, an act so intimate and socially meaningful, be transposed into virtual environments? Our study suggests that immersive dining can support new forms of connection, play, appreciation, and reflection. Yet it also reveals deeper tensions around embodiment, authenticity, and the social role of food. Eating is a profoundly embodied and relational act, tied to cultural identity, trust, and care [22]. Although participants valued the sensory layering and playful affordances of VR, some also worried about losing the immediacy and emotional resonance of physical meals. This concern aligns with critical HCI work cautioning against overtechnologising eating practices [13, 39]. **We argue that immersive dining should complement, not replace, physical commensality.** However, understanding how immersive environments reshape eating practices, bodily awareness, and social meaning remains an open and urgent question. This is further complicated by persistent ergonomic barriers, such as headset discomfort and fatigue, that constrain the naturalness of eating in VR. Moreover, even screen-based digital commensality, such as eating together via video call, remains relatively underexplored in HCI research. Comparative studies across physical, screen-mediated, and immersive technology-mediated eating experiences may offer deeper insights into how technology reshapes not only the meaning of eating together, but also the ways in which we feel, connect, and relate through food.

8.2 OS#2: How should we design immersive digital commensality experiences?

In developing our prototype, we made a series of deliberate design decisions, such as linking eating actions to environmental transformations, promoting low-pressure synchrony, and embedding multisensory cues. These decisions shaped the social dynamics we observed. However, other approaches to designing digital commensality could have led to different forms of interaction and connection. Our study highlights the need for a systematic framework to guide the design of socially immersive eating experiences.

While our design scaffolded shared attention and playful co-presence, future systems could experiment with **different balances between structure and emergence**. For instance, some experiences could script the meal as a tighter sequence of rituals, while others could leave the interaction more open-ended, relying on environmental affordances rather than explicit prompts. Research in social VR suggests that ambient, loosely structured spaces often trigger more authentic social bonding than heavily gamified or task-driven environments [12, 24]. Applying this insight to virtual commensality raises questions about how much, and what kind of guidance supports meaningful connection while eating together. **Cultural storytelling** and representation also demand careful design attention. While participants embraced the idea of "*traveling through food,*" previous research warns that superficial cultural representations, common in museum restaurants and tourist spaces, can break immersion or foster stereotypes [34, 36]. Future systems might explore **layered cultural narratives** that allow emotional engagement and deeper exploration, avoiding tokenism and inviting participant interpretation. To ensure authenticity and inclusivity, there is a strong need to **adopt co-design approaches**, involving people from the cultural contexts being represented, so that immersive commensality experiences reflect lived realities rather than simplified versions of culture.

To guide this emerging field, there is a need for a systematic design framework that maps how different factors, such as the degree of scripting, the rhythms of synchronisation, the layering of multisensory cues, and the framing of cultural narratives, influence the quality and meaning of shared eating in VR. Developing such a framework would help researchers and designers move beyond ad hoc experimentation toward more intentional, evidence-based approaches.

8.3 OS#3: When does food deepen multisensory immersion in VR?

Unlike most VR social interactions, which rely primarily on vision and hearing, immersive eating introduces an entirely different quality of engagement, one that activates taste, scent, texture, and embodied movement simultaneously. In our study, participants did not simply "*see*" or "*talk*" to each other: they **engaged multiple sensory channels** in parallel, creating a richer, more deeply felt form of co-presence. The act of eating in VR uniquely bridges the physical and virtual: while the food existed as a visual object in the virtual scene, it was simultaneously ingested in the real world, bringing together the digital and physical at the most visceral level. Our findings suggest that because it inherently engages multiple senses at once, food could be a particularly potent tool for enabling deeper immersion and social connection in virtual environments. Future research could further explore how different sensory arrangements including, but not limited to the Aristotelian senses (e.g., taste, scent, texture, temperature), **shape social outcomes** like trust, intimacy, and synchrony in immersive dining. Studies could systematically vary sensory inputs and compare their effects on group cohesion and emotional arousal, extending prior HCI findings that multisensory congruence enhances presence and engagement [14, 16, 53, 55]. Another promising direction is using crossmodal correspondences [45] (e.g., linking textures to environmental sounds) to subtly influence eating pace, mood, or shared rituals [17, 38, 43, 75], offering new tools for designing richer commensal experiences.

8.4 OS#4: Can immersive dining shift eating behaviours?

Immersive technologies have increasingly been explored as tools for behaviour change, from promoting physical activity [44], to supporting therapeutic interventions for phobias and pain management [23]. **Food and eating behaviours represent another promising, but yet underexplored, frontier**. Our findings suggest that VR dining experiences, by shaping the sensory and emotional dynamics of eating, could subtly but powerfully influence how people approach digital commensality.

Participants in our study sometimes altered their eating pace, portion sizes, or attention to internal cues not because they intended to, but as a byproduct of the immersive system design. For instance, some ate more than they normally would, driven by the environmental rewards, while others reported slowing down and appreciating the sensory richness of the meal. Given the global rise of eating-related challenges (e.g., mindless overeating in fast-paced environments, social isolation during meals), VR could offer novel avenues for intervention. Immersive meals could be designed to support slower, more intentional eating, help individuals reconnect with internal hunger and fullness cues, or reduce feelings of loneliness by enabling richer remote social dining.

However, challenges loom as well. Excessive multisensory stimulation or poorly timed interaction rhythms may overload users [41] and contribute to the reinforcement of unhealthy eating behaviours. Moreover, overly intrusive nudging may diminish trust or reduce the enjoyment associated with eating. Future research could examine how multisensory feedback influences portion control, satiety awareness, and eating enjoyment over time, and whether the effects observed in single sessions persist, fade, or transform with repeated use. Sustaining positive behaviours in immersive dining may require adaptive designs that evolve over time to prevent habituation and maintain engagement without manipulation. It is also important to investigate whether VR dining supports or disrupts self-regulation of eating pace and quantity. Further, designers must consider how immersive eating environments can balance sensory engagement with behavioural health goals, avoiding the risk of inducing pressure or guilt. Moreover, there is a need for longitudinal studies to evaluate the sustained impact of such interventions over time, particularly in understanding how long their behavioural and emotional effects last [20].

To operationalise these four opportunity spaces, we propose three directions. First, comparative studies should explore how physical, screen-based, and immersive dining impact embodiment, social presence, and sensory experience, using methods like behaviour tracking and in situ interviews. Second, a modular design framework should guide synchrony, narrative, and multisensory cues, developed via participatory design with culturally diverse users. Third, longitudinal studies should assess whether adaptive VR environments can promote mindful eating, regulate portions, and reduce loneliness without compromising trust or enjoyment. These steps support the transition from exploratory prototypes to evidence-based systems.

9 Limitations

While our study offers insights into the emerging space of immersive dining, several limitations must be acknowledged.

System specificity. The opportunity spaces we identified are shaped by our prototype's particular features, such as sensory feedback, environmental transformations, and snack-based eating. Different system designs may produce distinct behaviours or reflections, limiting generalisability to other immersive dining setups.

Scalability and cost. This study's manually operated VR setup limits generalisability. Given the low adoption and high cost of VR, scaling remains challenging. Future work should explore more automated and accessible systems. The prototype is thus positioned within a longer-term R&D trajectory rather than immediate commercial use, with broader deployment expected as VR becomes more affordable.

Scope of comparison. This study focused solely on immersive dining, without comparison to physical or screen-mediated commensality. Given differences in practices like utensil use and meal pacing, findings should be interpreted within the virtual context.

Sample size and participant traits. The small, demographically narrow sample limits generalisation. Participant openness to VR or novelty effects, especially among those new to immersive tech, may have positively biased their experiences.

Meal format constraints. Technical and ergonomic factors constrained the study to simple finger foods, not multi-course meals with utensils. Insights therefore reflect casual eating more than formal dining rituals.

10 Conclusion

This paper explored how immersive technologies can reshape shared eating experiences, moving beyond replication toward new forms of sensory, social, and emotional connection. Our findings suggest that immersive dining offers rich opportunities for reimagining commensality, but also raises important questions about embodiment, authenticity, and ethical design. Future work must build careful, user-centred frameworks to guide the development of meaningful, inclusive, and responsible immersive eating experiences.

References

[1] Khawla Alhasan, Eleonora Ceccaldi, Alexandra Covaci, Maurizio Mancini, Ferran Altarriba Bertran, Gijs Huisman, Mailin Lemke, and Chee Siang Ang. 2022. The playful potential of digital commensality: learning from spontaneous playful remote dining practices. *Proceedings of the ACM on Human-Computer Interaction* 6, CHI PLAY (2022), 1–24.

[2] Laurence Allard, Joceline Andersen, Emily Buddle, Robin Caldwell, Sarah Cramer, Gaby David, Sara Garcia Santamaria, Deborah Harris, KC Hysmith, Alex Ketchum, et al. 2022. *Food Instagram: Identity, influence, and negotiation.* University of Illinois Press.

[3] Ferran Altarriba Bertran, Samvid Jhaveri, Rosa Lutz, Katherine Isbister, and Danielle Wilde. 2019. Making sense of human-food interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems.* 1–13.

[4] Charles White and. 2025. Embodied resonance in technology-mediated group music-making. *International Journal of Performance Arts and Digital Media* 0, 0 (2025), 1–23. doi:10.1080/14794713.2025.2473139 arXiv:https://doi.org/10.1080/14794713.2025.2473139

[5] Laurensia Anjani, Terrance Mok, Anthony Tang, Lora Oehlberg, and Wooi Boon Goh. 2020. Why Do People Watch Others Eat Food? An Empirical Study on the Motivations and Practices of Mukbang Viewers. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–13. doi:10.1145/3313831.3376567

[6] Amanda Björnwall, Ylva Mattsson Sydner, Afsaneh Koochek, and Nicklas Neuman. 2021. Eating alone or together among community-living older people—A scoping review. *International journal of environmental research and public health* 18, 7 (2021), 3495.

[7] Sara N Bleich, Christina D Economos, Marie L Spiker, Kelsey A Vercammen, Eric M VanEpps, Jason P Block, Brian Elbel, Mary Story, and Christina A Roberto. 2017. A systematic review of calorie labeling and modified calorie labeling interventions: impact on consumer and restaurant behavior. *Obesity* 25, 12 (2017), 2018–2044.

[8] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[9] Virginia Braun and Victoria Clarke. 2021. One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative research in psychology* 18, 3 (2021), 328–352.

[10] Merijn Bruijnes, Gijs Huisman, and Dirk Heylen. 2016. Tasty Tech: Human-Food Interaction and Multimodal Interfaces. In *Proceedings of the 1st Workshop on Multi-Sensorial Approaches to Human-Food Interaction* (Tokyo, Japan) *(MHFI '16)*. Association for Computing Machinery, New York, NY, USA, Article 4, 6 pages. doi:10.1145/3007577.3007581

[11] Wonjeong Chae, Yeong Jun Ju, Jaeyong Shin, Sung-In Jang, and Eun-Cheol Park. 2018. Association between eating behaviour and diet quality: eating alone vs. eating with others. *Nutrition journal* 17, 1 (2018), 1–11.

[12] Hsin-I Chen and Ana Sevilla-Pavón. 2023. Negotiation of meaning via virtual exchange in immersive virtual reality environments. (2023).

[13] Jaz Hee-jeong Choi, Conor Linehan, Rob Comber, and John McCarthy. 2012. Food for thought: designing for critical reflection on food practices. In *Proceedings of the Designing Interactive Systems Conference.* 793–794.

[14] Ioan-Sorin Comşa, Estêvão Bissoli Saleme, Alexandra Covaci, Gebremariam Mesfin Assres, Ramona Trestian, Celso AS Santos, and Gheorghiţă Ghinea. 2019. Do I smell coffee? The tale of a 360 mulsemedia experience. *IEEE MultiMedia* 27, 1 (2019), 27–36.

[15] Alexandra Covaci, Khawla Alhasan, Mayank Loonker, Bernardine Farrell, Luma Tabbaa, Sophia Ppali, and Chee Siang Ang. 2023. No Pie in the (Digital) Sky: Co-Imagining the Food Metaverse. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems.* 1–17.

[16] Alexandra Covaci, Gheorghita Ghinea, Chang-Hsin Lin, Shu-Hsien Huang, and Ju-Ling Shih. 2018. Multisensory games-based learning-lessons learnt from olfactory enhancement of a digital board game. *Multimedia Tools and Applications* 77 (2018), 21245–21263.

[17] Alexandra Covaci, Estêvão Bissoli Saleme, Gebremariam Mesfin, Nadia Hussain, Elahe Kani-Zabihi, and Gheorghita Ghinea. 2019. How do we experience crossmodal correspondent mulsemedia content? *IEEE Transactions on Multimedia* 22, 5 (2019), 1249–1258.

[18] Renata Fiche da Mata Gonçalves, Danyela de Almeida Barreto, Pâmela Ione Monteiro, Márcio Gilberto Zangeronimo, Paula Midori Castelo, Andries van der Bilt, and Luciano José Pereira. 2019. Smartphone use while eating increases caloric ingestion. *Physiology & behavior* 204 (2019), 93–99.

[19] Jialin Deng, Ferran Altarriba Bertran, Marianna Obrist, Yan Wang, Carlos Velasco, et al. 2022. Sketching the future of human-food interaction: Emerging directions for future practice. *International Journal of Gastronomy and Food Science* (2022), 100629.

[20] Anna Flavia Di Natale, Silvia Francesca Maria Pizzoli, Giulia Brizzi, Daniele Di Lernia, Fabio Frisone, Andrea Gaggioli, Elisa Rabarbari, Osmano Oasi, Claudia Repetto, Chiara Rossi, et al. 2024. Harnessing immersive virtual reality: A comprehensive scoping review of its applications in assessing, understanding, and treating eating disorders. *Current Psychiatry Reports* 26, 9 (2024), 470–486.

[21] Feng Ding, Nazimah Hamid, Daniel Shepherd, and Kevin Kantono. 2019. How is satiety affected when consuming food while working on a computer? *Nutrients* 11, 7 (2019), 1545.

[22] Claude Fischler. 1988. Food, self and identity. *Social science information* 27, 2 (1988), 275–292.

[23] Daniel Freeman, Polly Haselton, Jason Freeman, Bernhard Spanlang, Sameer Kishore, Emily Albery, Megan Denne, Poppy Brown, Mel Slater, and Alecia Nickless. 2018. Automated psychological therapy using immersive virtual reality for treatment of fear of heights: a single-blind, parallel-group, randomised controlled trial. *The Lancet Psychiatry* 5, 8 (2018), 625–632.

[24] Guo Freeman and Dane Acena. 2021. Hugging from a distance: Building interpersonal relationships in social virtual reality. In *ACM international conference on interactive media experiences.* 84–95.

[25] Ayaka Fujii, Kanae Kochigami, Shingo Kitagawa, Kei Okada, and Masayuki Inaba. 2020. Development and evaluation of mixed reality co-eating system: Sharing the behavior of eating food with a robot could improve our dining experience. In *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN).* IEEE, 357–362.

[26] William Gaver. 2012. What should we expect from research through design?. In *Proceedings of the SIGCHI conference on human factors in computing systems.* 937–946.

[27] Tom Gayler, Corina Sas, and Vaiva Kalnikaite. 2019. Taste Your Emotions: An Exploration of the Relationship between Taste and Emotional Experience for HCI. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. Association for Computing Machinery, New York, NY, USA, 1279–1291. doi:10.1145/3322276.3322336

[28] Tom Gayler, Corina Sas, and Vaiva Kalnikaitė. 2022. Exploring the design space for human-food-technology interaction: An approach from the lens of eating experiences. *ACM Transactions on Computer-Human Interaction* 29, 2 (2022), 1–52.

[29] Saumya Gupta, Ferran Altarriba Bertran, Oðuz 'Oz' Buruk, Sara Milkes Espinosa, Theresa Jean Tanenbaum, and Minerva Wu. 2021. Exploring Food Based Interactive, Multi-Sensory, and Tangible Storytelling Experiences. In *Proceedings of the 2021 ACM Designing Interactive Systems Conference* (Virtual Event, USA) *(DIS '21)*. Association for Computing Machinery, New York, NY, USA, 651–665. doi:10.1145/3461778.3462006

[30] Saumya Gupta, Ferran Altarriba Bertran, Oðuz 'Oz'Buruk, Sara Milkes Espinosa, Theresa Jean Tanenbaum, and Minerva Wu. 2021. Exploring Food based Interactive, Multi-Sensory, and Tangible Storytelling Experiences. In *Designing Interactive Systems Conference 2021.* 651–665.

[31] Myrte Esther Hamburg, Catrin Finkenauer, and Carlo Schuengel. 2014. Food for love: the role of food offering in empathic emotion regulation. *Frontiers in psychology* 5 (2014), 32.

[32] Felix Heidrich, Kai Kasugai, Carsten Röcker, Peter Russell, and Martina Ziefle. 2012. RoomXT: advanced video communication for joint dining over a distance. In *2012 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops.* IEEE, 211–214.

[33] Hyeji Kim, Jing Chen, Euiyoung Kim, and Alice M Agogino. 2017. Scenario-based conjoint analysis: measuring preferences for user experiences in early stage design. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, Vol. 58219. American Society of Mechanical Engineers, V007T06A042.

[34] Sangkyun Kim, Eerang Park, and Min Xu. 2020. Beyond the authentic taste: The tourist experience at a food museum restaurant. *Tourism Management Perspectives* 36 (2020), 100749.

[35] Yujeong Kim, Eunmi Lee, and Haeyoung Lee. 2020. Characteristics of eating alone affecting the stress, depression, and suicidal ideation. *Community mental health journal* 56 (2020), 1603–1609.

[36] Volker Kirchberg and Martin Tröndle. 2012. Experiencing exhibitions: A review of studies on visitor experiences in museums. *Curator: the museum journal* 55, 4 (2012), 435–452.

[37] Veronika Krauß, Michael Nebeling, Florian Jasche, and Alexander Boden. 2022. Elements of xr prototyping: Characterizing the role and use of prototypes in augmented and virtual reality design. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–18.

[38] Jinha Lee and Heejin Lim. 2022. Design matters: Cross-modal correspondences between vision and taste in food advertising. *Journal of Marketing Communications* 28, 2 (2022), 132–151.

[39] Deborah Lupton. 1996. Food, the Body and the Self. (1996).

[40] Michael Macht, Jessica Meininger, and Jochen Roth. 2005. The pleasures of eating: A qualitative analysis. *Journal of Happiness Studies* 6, 2 (2005), 137–160.

[41] Naresh K Malhotra. 1984. Information and sensory overload. Information and sensory overload in psychology and marketing. *Psychology & Marketing* 1, 3-4 (1984), 9–21.

[42] Divine Maloney and Guo Freeman. 2020. Falling asleep together: What makes activities in social virtual reality meaningful to users. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. 510–521.

[43] Gebremariam Mesfin, Nadia Hussain, Elahe Kani-Zabihi, Alexandra Covaci, Estêvão B Saleme, and Gheorghita Ghinea. 2020. QoE of cross-modally mapped Mulsemedia: an assessment using eye gaze and heart rate. *Multimedia Tools and Applications* 79 (2020), 7987–8009.

[44] Alessio Mocco, Lucia Valmaggia, Lara Bernardi, Margherita Alfieri, and Ilaria Tarricone. 2024. Enhancing physical activity with immersive virtual reality: A systematic review. *Cyberpsychology, Behavior, and Social Networking* 27, 5 (2024), 303–317.

[45] Kosuke Motoki, Lawrence E Marks, and Carlos Velasco. 2023. Reflections on cross-modal correspondences: Current understanding and issues for future research. *Multisensory Research* 37, 1 (2023), 1–23.

[46] Mamoun Nawahdah and Tomoo Inoue. 2013. Virtually dining together in time-shifted environment: KIZUNA design. In *Proceedings of the 2013 conference on Computer supported cooperative work*. 779–788.

[47] Radoslaw Niewiadomski, Merijn Bruijnes, Gijs Huisman, Conor Patrick Gallagher, and Maurizio Mancini. 2022. Social robots as eating companions. *Frontiers in Computer Science* 4 (2022), 909844.

[48] Radoslaw Niewiadomski, Eleonora Ceccaldi, Gijs Huisman, Gualtiero Volpe, and Maurizio Mancini. 2019. Computational Commensality: From Theories to Computational Models for Social Food Preparation and Consumption in HCI. *Frontiers in Robotics and AI* 6 (2019). doi:10.3389/frobt.2019.00119

[49] Marianna Obrist, Yunwen Tu, Lining Yao, and Carlos Velasco. 2019. Space food experiences: designing passenger's eating experiences for future space travel scenarios. *Frontiers in Computer Science* 1 (2019), 3.

[50] Junhee Park, Hyung Eun Shin, Miji Kim, Chang Won Won, and Yun-Mi Song. 2022. Longitudinal association between eating alone and deterioration in frailty status: The Korean Frailty and Aging Cohort Study. *Experimental Gerontology* (2022), 112078.

[51] Olivia Petit, Carlos Velasco, Qian Janice Wang, and Charles Spence. 2022. Consumer consciousness in multisensory extended reality. *Frontiers in psychology* 13 (2022), 851753.

[52] Nimesha Ranasinghe, Pravar Jain, Shienny Karwita, and Ellen Yi-Luen Do. 2017. Virtual lemonade: Let's teleport your lemonade!. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction*. 183–190.

[53] Nimesha Ranasinghe, Pravar Jain, Shienny Karwita, David Tolley, and Ellen Yi-Luen Do. 2017. Ambiotherm: enhancing sense of presence in virtual reality by simulating real-world environmental conditions. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. 1731–1742.

[54] Nimesha Ranasinghe, Kuan-Yi Lee, Gajan Suthokumar, and Ellen Yi-Luen Do. 2014. Taste+ digitally enhancing taste sensations of food and beverages. In *Proceedings of the 22nd ACM International Conference on Multimedia*. 737–738.

[55] Jussi Rantala, Katri Salminen, Poika Isokoski, Ville Nieminen, Markus Karjalainen, Jari Väliaho, Philipp Müller, Anton Kontunen, Pasi Kallio, and Veikko Surakka. 2024. Recall of odorous objects in virtual reality. *Multimodal Technologies and Interaction* 8, 6 (2024), 42.

[56] Elizabeth B-N Sanders and Pieter Jan Stappers. 2008. Co-creation and the new landscapes of design. *Co-design* 4, 1 (2008), 5–18.

[57] Jeffery Sobal and Mary K Nelson. 2003. Commensal eating patterns: a community study. *Appetite* 41, 2 (2003), 181–190.

[58] Giuseppina Spano, Annalisa Theodorou, Gerhard Reese, Giuseppe Carrus, Giovanni Sanesi, and Angelo Panno. 2023. Virtual nature, psychological and psychophysiological outcomes: A systematic review. *Journal of Environmental Psychology* 89 (2023), 102044. doi:10.1016/j.jenvp.2023.102044

[59] Charles Spence. 2017. *Gastrophysics: The new science of eating*. Penguin UK.

[60] Charles Spence, Maurizio Mancini, and Gijs Huisman. 2019. Digital commensality: Eating and drinking in the company of technology. *Frontiers in psychology* 10 (2019), 2252.

[61] Charles Spence and Carlos Velasco. 2025. *Digital dining: New innovations in food and technology*. Springer.

[62] Bronwyn Tarr, Mel Slater, and Emma Cohen. 2018. Synchrony and social connection in immersive virtual reality. *Scientific reports* 8, 1 (2018), 3693.

[63] Annalisa Theodorou, Giuseppina Spano, Gregory N Bratman, Kevin Monneron, Giovanni Sanesi, Giuseppe Carrus, Claudio Imperatori, and Angelo Panno. 2023. Emotion regulation and virtual nature: cognitive reappraisal as an individual-level moderator for impacts on subjective vitality. *Scientific Reports* 13, 1 (2023), 5028.

[64] Jordan D Troisi, Shira Gabriel, Jaye L Derrick, and Alyssa Geisler. 2015. Threatened belonging and preference for comfort food among the securely attached. *Appetite* 90 (2015), 58–64.

[65] Hitomi Tsujita, Svetlana Yarosh, and Gregory D Abowd. 2010. CU-Later: a communication system considering time difference. In *Proceedings of the 12th ACM international conference adjunct papers on Ubiquitous computing-Adjunct*. 435–436.

[66] Carlos Velasco and Marianna Obrist. 2020. *Multisensory experiences: Where the senses meet technology*. Oxford University Press.

[67] Carlos Velasco, Marianna Obrist, Olivia Petit, and Charles Spence. 2018. Multisensory technology for flavor augmentation: a mini review. *Frontiers in psychology* 9 (2018), 26.

[68] Carlos Velasco, Qian Janice Wang, Marianna Obrist, and Anton Nijholt. 2021. A Reflection on the State of Multisensory Human–Food Interaction Research. *Frontiers in Computer Science* 3 (2021), 694691.

[69] Jonas Wagener, Susanne Boll, and Lukas Unzner. 2022. Multisensory Feedback in Virtual Reality for Mindfulness: Exploring the Effects of Passive Haptics and Audio. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*. ACM, 1–6. doi:10.1145/3491101.3519672

[70] Qian Janice Wang, Francisco Barbosa Escobar, Patricia Alves Da Mota, and Carlos Velasco. 2021. Getting started with virtual reality for sensory and consumer science: Current practices and future perspectives. *Food Research International* 145 (2021), 110410.

[71] Xinyi Wang, Wei Shen, Chunmei Wang, Xiaoyi Zhang, Yuanyuan Xiao, Fan He, Yujia Zhai, Fudong Li, Xiaopeng Shang, and Junfen Lin. 2016. Association between eating alone and depressive symptom in elders: a cross-sectional study. *BMC geriatrics* 16, 1 (2016), 1–10.

[72] Jun Wei, Xuan Wang, Roshan Lalintha Peiris, Yongsoon Choi, Xavier Roman Martinez, Remi Tache, Jeffrey Tzu Kwan Valino Koh, Veronica Halupka, and Adrian David Cheok. 2011. CoDine: an interactive multi-sensory system for remote dining. In *Proceedings of the 13th international conference on Ubiquitous computing*. 21–30.

[73] Carolin Wienrich, Nina Döllinger, and Rebecca Hein. 2021. Behavioral framework of immersive technologies (BehaveFIT): How and why virtual reality can support behavioral change processes. *Frontiers in Virtual Reality* 2 (2021), 627194.

[74] Zara Worth. 2018. Shared Meals: Instagram as a space for virtual feasting and rites of incorporation. *Feast* (2018).

[75] Chengyan Xu, Michael Siegrist, and Christina Hartmann. 2021. The application of virtual reality in food consumer behavior research: A systematic review. *Trends in Food Science & Technology* 116 (2021), 533–544.