pic2eat: Facilitating Social Ice-breaking through Collaborative Design of 3D Printed Appetizer

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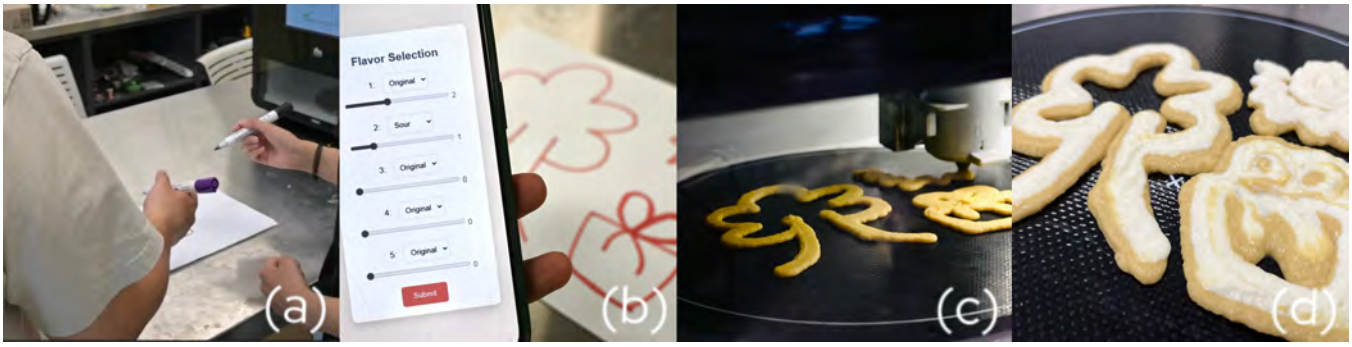

Figure 1: (a) Participants are collaborating and communicating to create a simple sketch. (b) Participants are using *pic2eat* to upload their creations, customizing unique flavors and proportions. (c) The 3D food printer is printing their creations. (d) Participants have completed their jointly designed appetizer using *pic2eat*.

ABSTRACT

3D Food Printing (3DFP), emerging as a multifaceted technology in domestic, gastronomic, and various industrial settings, presents underexplored opportunities for facilitating social interaction. To address this, this research engaged culinary professionals along with participants from diverse backgrounds to investigate the application of 3DFP in social contexts. Consequently, we introduce *pic2eat*, an innovative 3DFP system that facilitates collaborative artistic expression among unfamiliar individuals through the creation of jointly-designed appetizer with distinct flavor profiles. Our goal was to explore the potential efficacy of 3DFP technology in catalyzing the initiation of social relationships. In our pilot study, the *pic2eat* was deployed in an experimental setting involving three pairs of strangers. The empirical results suggest that the system is not only accessible and user-friendly, but also significantly effective in mitigating initial social discomfort, thereby enhancing interpersonal engagement. Through this research, we underscores the potential of 3DFP in augmenting social interaction through

CHI EA '24, May 11–16, 2024, Honolulu, HI, USA

ACM ISBN 979-8-4007-0331-7/24/05
https://doi.org/10.1145/3613905.3651082

a synergistic approach that combines creative collaboration and communal dining experiences.

CCS CONCEPTS

• **Human-centered computing → Interaction design**; **User studies**.

KEYWORDS

3D food printing, Ice breaking activities, Human-food interaction

ACM Reference Format:
Hongyue Wang, Jialin Deng, Aravind Mohan, Yinyi Li, Hao Peng, Linjia He, Don Samitha Elvitigala, and Florian 'Floyd' Mueller. 2024. pic2eat: Facilitating Social Ice-breaking through Collaborative Design of 3D Printed Appetizer. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '24), May 11–16, 2024, Honolulu, HI, USA.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3613905.3651082

1 INTRODUCTION

Imagine yourself at a social gathering, keen to forge new friendships. How might you navigate the initial awkwardness and establish meaningful connections in such a setting? A common strategy is to find common ground, such as talking about weather changes or shared interests, as an opportunity to break the silence. However, this process is often challenging, as tension and discomfort can stem from various factors, such as social anxiety, language barriers, or cultural backgrounds. Therefore, finding a natural and enjoyable way to facilitate communication and establish connections becomes crucial in different settings, whether formal business events or casual private gatherings.

Research has shown that strangers can move towards embodied and harmonious relationships through behavioral synchronization [30]. Some research introduces social robots [34], interactive games [14], or wearable [15] as ice-breaking tools to help overcome the awkwardness of first meetings and promote communication. These studies are dedicated to establishing connections through common activities or experiences. However, the significant role of food in social gatherings seems to be overlooked; it is a natural social catalyst that brings people closer together. But the food preparation process often requires specific skills and time. In the context of social gatherings, food interaction technology, especially 3D food printing [35], offers the potential to quickly and personalized produce various shapes, flavors, and nutritional components of food, providing great ice-breaking potential for social occasions.

During social gatherings, appetizers are not only served to stimulate appetite before meals but also, as a type of food, symbolize the centerpiece of social interaction [28]. Building on this, we developed an interactive culinary system, called *pic2eat*, which can serve as the gateway to social engagement. Our system is designed with the purpose of facilitating ice-breaking in social settings and provide a central hub for interaction. In a pilot study involving 3 pairs of participants, they engaged in joint decision-making, responded to random prompts from the system, and collaboratively designed a personalized appetizer, tailoring its flavor and proportions to their preferences. Our findings indicate that this process can potentially encourage communication and collaboration. This collaborative effort appeared to naturally dissolve social barriers, fostering a sense of community through a shared creative culinary experience.

Taken together, our contributions include:

- The introduction of a novel system that harnesses 3D Food Printing technology to aid in initiating interactions at social gatherings, effectively serving as an ice-breaker.
- An initial empirical exploration via a pilot study of the *pic2eat* system, providing a foundational understanding of its impact and effectiveness in real-world scenarios.

2 RELATED WORK

In this section, we primarily start from research related to facilitating ice-breaking activities, exploring the practice of using food interaction technology to promote socialization in the field of Human-Food Interaction (HFI), and the research potential of 3D Food Printing.

2.1 Interactive technologies in Enhancing Social Ice-breaking

The process of establishing relationships between strangers is often hampered by social etiquette [29], excessive concern about the negative consequences of socializing [7, 8], and limitations to superficial topics [16]. Therefore, ice-breaking activities have become an important part of fostering interpersonal relationships. They help participants overcome nervousness and social barriers, guiding them towards positive communication and socialization [23]. With technological advancements, ice-breaking activities have expanded from traditional physical games [25, 26] to electronic games [14, 27], social robots [34], and even wearables [15]. We realize that interactive technology can act as a conversation facilitator in social environments, helping strangers establish closer connections[34].

2.2 Food Interaction Technology Promoting Socialization

In daily family and community life, food often becomes the center of social interaction, entertainment, and cultural expression [6]. It not only has nutritional value but also carries strong social attributes and societal benefits [4, 22]. Particularly, food is considered a symbolic medium rich in emotional connections, capable of conveying and stimulating positive emotions [32].

In the field of HFI, researchers hope to enhance social engagement and interactive experiences through food interaction technologies, particularly by celebrating with food as a medium [13]. For instance, Yan et al. developed iScream which can generate interactive rhythm through licking ice cream, thereby promoting interaction in face-to-face situations [31]. And "You better eat to survive" promotes socialization through cooperative eating in virtual spaces [1]. Additionally, researchers have tried to establish remote interactive dining platforms, helping people maintain contact with distant family and friends by participating in remote communal dinners [2]. However, prior works in this domain have largely overlooked the aspect of collaborative creation, leaving such interactions insufficiently examined.

Our research uniquely employs the generative capabilities of 3DFP technology to foster collaborative endeavors. We utilize 3DFP

as an interactive medium to investigate the potential of food interaction technology in establishing social connections, specifically focusing on its ability to facilitate ice-breaking in social settings. This approach marks a distinct shift from the conventional applications of 3DFP, directing attention towards its social and interactive potentials. Simultaneously, it is important to emphasize that the purpose of this research is to offer a new possibility for social ice-breaking through collaborative food creation, rather than to replace any specific technology.

2.3 3D Food Printing in HFI

In filed of HFI, several studies have used 3DFP technology to create edible interfaces to enhance the food experience [10]. For example, the Edipulse explores the application of 3DFP in supporting physical activity experiences by monitoring exercise data and transforming it into chocolate patterns [17]. The Data Jalebi Bot collects personal information from diners, maps it to different patterns, and prints unique Indian sweets [24]. These studies explore edible visual experiences based on 3DFP, but they usually focus only on a single flavor, overlooking the interactive potential of multiple flavor combinations. To address this, the CoDine platform transmits organic food to remote locations through 3DFP, incorporating multi-flavor food attributes like olfactory and taste combinations [33]. However, current 3DFP interactive research remains limited to preset printing parameters and 3D models, lacking flexibility in personalization and real-time production [11].

Thus, we identify the following research gaps from previous studies: 1. Food interaction technology has potential in promoting social relationships, but existing HFI research focuses more on intensifying and bonding social relationships, overlooking the collaborative process of initiating social relationships; 2. Current HFI research in 3DFP mostly focuses on single flavors and visual elements, neglecting the exploration of dynamic changes and combinations of different tastes; 3. Existing HFI research has not fully utilized real-time user responses and preferences to create personalized 3DFP food. In response, our research seeks to answer the question: How can we design interactive 3D Food Printing systems to facilitate collaborative culinary creations, thereby enriching social engagement?

3 METHODOLOGY

Our research follows the Human-Centered Design (HCD) [5] and Constructive Design Research methods [19]. We adopted these approaches to develop ice-breaking concepts centered around food interaction technology, aiming to meet users' social needs. By implementing HCD, we placed users' needs and experiences at the core of the design process. Simultaneously, we employed Constructive Design Research method, which is intended to assist researchers in exploring and realizing new design ideas, generating new knowledge and understanding through design practice. Based on the principles of HCD, our constructive design research was divided into three phases, as shown in Figure 2.

In the first phase of our research, we focused on understanding user needs in the context of social ice-breaking. Firstly, we conducted interviews with 4 experts in the catering industry. This step aimed to gather comprehensive insights into their experiences with

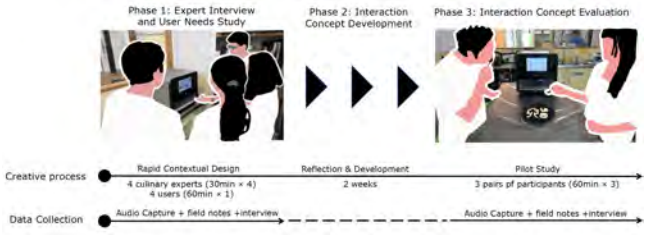

Figure 2: Schematic flow of the study.

3DFP technology and their views on culinary production, thereby delineating the scope of research possibilities for 3DFP in this domain. Secondly, we organized a social event centered around 3DFP. This provided an observational platform to examine participant interactions with 3DFP technology. Additionally, we collected feedback from the participants, which offered valuable perspectives on our research topic (articulated in section 4).

In the second phase of our research, we progressed to the development of an interactive system incorporating 3DFP technology. This phase was directly influenced by the insights and understanding gleaned from expert opinions and user needs identified in the initial phase. The design and functionality of the 3DFP-based system were tailored to address the specific requirements and preferences highlighted in our earlier research, ensuring its relevance and effectiveness in the intended context (detailed in section 5).

In the third phase, we conducted a study aimed to evaluate our system developed in the second stage. We focused on gathering user feedback, which was instrumental in understanding the system's effectiveness, user experience, and areas for potential improvement. This evaluation was key to refining our approach and validating the utility of the system in the context for which it was designed (articulated in section 6).

During every user study, we conducted a 30-minute group semi-structured interview. We took field notes, photos and recorded each interview, then transcribed all interview data. Next, we processed the interview data using Nvivo software and conducted thematic analysis [3].

4 PHASE 1: EXPERT INTERVIEW AND USER NEEDS STUDY

This phase focuses on user needs research in the context of social ice-breaking, aiming to explore the potential of 3DFP in facilitating social interactions and how it can help users establish social connections.

4.1 Participants

In this phase, we initially invited four experienced and diverse culinary experts for a 30-minute semi-structured interview each. These experts (M=29.25, STD=29.58) included a barista (P1), a dessert chef (P2), and two bakers (P3, P4), with their culinary experience ranging from 5 to 15 years (M=9.25, STD=21.58). Through their experience in food preparation and insights into 3DFP, we aimed to deeply understand the research potential of 3DFP from a professional perspective.

Next, we invited four participants (P5, P6, P7, P8) who were enthusiastic about meeting new people in social events, and organized a social gathering themed around 3D food printing (M=25.25, STD=4.92). During this event, participants used the built-in functions and patterns of the 3D food printer, along with prepared printing materials, to engage in the interactive process of 3D food printing. Most participants had no prior exposure to the concept and operation of 3DFP. We observed their behavior in using 3DFP for social ice-breaking and conducted a 30-minute group semi-structured interview to gather their feedback and expectations on using 3DFP as a social ice-breaking tool. In this study, we used the extrusion-based 3DFP printer Foodini [9] developed by Natural Machines.

4.2 Findings and Discussion

4.2.1 The Potential of 3DFP from Experts' Perspective. From the chefs' viewpoint, they see significant research potential in 3DFP for visual design, flavor innovation, and proportion control.

Food appearance and aesthetic appeal. The chefs emphasized that while the taste of food is crucial, its appearance is equally important. They noted that 3DFP technology positively impacts the aesthetic enhancement of decorations. For instance, P1 discussed the appeal of food aesthetics to consumers in the current trend of photo sharing, stating, *"3DFP can achieve a level of precision unattainable by handcrafting."* P3 cited examples from French pastries and artistic bread competitions using fondant for exquisite appearances, adding, *"It's hard to express the taste experience of food, but if I create a visual impact, such as plating, it will attract more customers."*

Flavor Exploration and Balance. Most chefs mentioned that the diversity of flavors adds layers to food. 3DFP technology can create unique composite flavors by controlling combinations of different ingredients. However, P1 and P4, using coffee and wheat bread as examples, believed that the flavor of food should remain simple and highlight the original taste without being overshadowed by another flavor.

Proportion Control. All chefs agreed that 3DFP is significant in maintaining the stability of ingredient proportions. P2 mentioned that adjusting proportions is crucial in food preparation, *"When we make a dish, we need to adjust the proportions. Once these are set, we must ensure that every preparation revolves around these proportions, otherwise, it affects the texture and taste."*

4.2.2 Social Ice-breaking Needs from Users' Perspective. From the users' perspective, they hoped that 3DFP could meet personalized customization needs and reduce awkwardness in social ice-breaking through guidance and co-creation.

Personalized customization and exploration. We noticed that users showed great interest in various 3D food model designs within the Foodini system. P6 said, *"If I could use it to create a detailed dragon-shaped bread structure, that would be amazing."* However, after interacting with 3DFP, users found that even simple shapes were challenging to achieve. P8 questioned, *"Do we need to learn additional techniques to control it to print unique food?"*, which means that participants still have requirements for the personalized design of 3DFP.

Facilitating Interpersonal Relationships. We observed that participants unanimously considered using 3DFP interaction as a novel ice-breaking concept. P5 recalled, *"I remember my relationship with my friends becoming closer, starting from dining together,"* suggesting that 3DFP has the potential to serve as a tool for promoting interpersonal relationships.

Collaboration and Natural Interaction. Each participant had experienced awkward ice-breaking moments. P7 shared an experience of being asked by a teacher to embarrass oneself in front of classmates, *"I felt very uncomfortable with forced ice-breaking activities."* They agreed that the ice-breaking process should be natural and focused, avoiding being forced or dominated. While, P6 emphasized the importance of a facilitator in the ice-breaking process, *"Aimless ice-breaking is ineffective; proper guidance is necessary."* P5 pointed out that traditional group games like UNO and Pictionary, though fun, do not allow for a deep understanding of individuals. Therefore P5 suggests, *"Completing a common goal promotes more effective communication."*

Reflecting on these viewpoints, we realize that while 3D food printing technology can create intricate structures difficult to achieve by our hands, its complex modeling process and programming control are significant barriers for ordinary users. Our focus should be on how to use 3DFP and visually appealing, tasty food to allow everyone to design their food without extensive knowledge of food science or artistic aesthetics. We believe that the next phase of interaction system design should fully utilize the features of 3DFP, such as personalized appearance customization, exploring different flavors and their proportions to create unique tastes, but the flavor combinations should not be overly complex. Additionally, interaction design should reduce awkwardness in social processes through guidance or prompts and promote natural social relationship building by completing tasks together.

5 PHASE 2: INTERACTION CONCEPT DEVELOPMENT

Following the user study results, we developed *pic2eat*, an interactive application designed to enhance mutual understanding and reduce social barriers in gatherings. It randomly generates prompts that encourage users to collaboratively design and choose flavors and proportions for a personalized appetizer, as shown in Figure 3.

Figure 3: The mechanism of pic2eat.

According to the 22 playful factors from PLEX card [21], developers set up a prompt library containing 22 random emotional messages (see the APPENDICES) to inspire participants for co-creation in *pic2eat*. Users first click the "prompt" button on the homepage to get the random background information for their creation. Then, two participants brainstorm together and use markers to draw a simple sketch on paper that revolve around the background information, forming the visual design of the appetizer. After drawing,

users click the "enable camera" button to capture their artwork and upload to the cloud. We noticed that ambient lighting often caused shadows in the drawings during the upload process. To address this, we performed binarization on the images and applied the Otsu algorithm [20] to automatically determine the optimal black-and-white threshold for the images, eliminating the impact of shadows on subsequent 3D food printing.

After completing the drawing, participants can communicate and reflect based on the background prompts and their creation. Within the flavor selection interface of *pic2eat*, the application harnesses the 3D food printer's capacity for precise layer-by-layer deposition to enable users to calibrate the proportion of each flavor. This calibration is achieved through the selection of taste preferences and the adjustment of a corresponding slider (range 0-5), thereby dictating the specific volume allocation for printing. Upon the completion of their visual design and the meticulous determination of flavor proportions, users are required to submit these details. Subsequently, the system convert this information into printable gcode format and produce collaboratively created appetizer.

6 PHASE 3: INTERACTION CONCEPT EVALUATION

In this phase, we conducted a second user study to observe how participants use *pic2eat* for social ice-breaking and their interactive experience.

6.1 Selection of Printing Materials

The key to successful 3D food printing lies in the choice of materials: they need to have good print ability, adaptability to design, and post-processing capability [12]. Specifically, food materials need to be suitable for printing, capable of maintaining the integrity of the model, and able to withstand subsequent cooking steps. As part of pic2eat's preliminary exploration of how various flavors and their combinations can facilitate the creation of 3DFP food, we have selected five common tastes from daily life: hummus (tasteless), Greek yogurt (sour), strawberry jam (sweet), bitter gourd sauce (bitter), and chili sauce (spicy) for initial flavor customization (for the process of printing materials, see APPENDICES). Additionally, to ensure the best 3D printing effect, we precisely calibrated the printing parameters for each ingredient and used a 4mm printing nozzle. Before the start of user studies, researchers needed to prepare these five printing materials in advance, as shown in Figure 4.

Figure 4: Taking the preparation of hummus as an example, (a) represents the preparation of hummus, (b) displays the consistency of printable ingredients, (c) fills hummus into the printing capsule, and (d) displays the five printing materials.

6.2 Participants

This user study invited three pairs of strangers (P1&P2, P3&P4, P5&P6), totaling six people (five males, M=26.83, STD=3.14). Their task was to assess the potential of the *pic2eat* system in facilitating social ice-breaking and to explore the dynamics and experiences of participant relationships during the interaction. These participants were recruited through a combination of snowball methods. Most had no prior experience with 3D food printers. Additionally, most of them reported difficulties in breaking the ice and initiating new friendships in their daily lives.

6.3 Research Design

Three user studies were conducted in sessions lasting one hour each. Each session comprised two parts: a 30-minute co-creation phase, followed by a 30-minute semi-structured interview. During the user study, researchers first introduced the background of the study to the participants and demonstrated how to use the *pic2eat* application. Then, they showed the participants the edible printing materials and sequentially installed pre-prepared printing capsules of these ingredients into the 3D food printer. Guided by the prompt, two participants communicated, discussed, and jointly drew a simple sketch representing the creative prompt, and saved it in the cloud through photography. Subsequently, they exchanged ideas and chose the flavors and proportions for the appetizer. During the printing process, the participants chatted about their creation and began to learn about each other. After printing, they tasted their creation together and participated in a semi-structured interview.

6.4 Evaluation Findings and Discussion

6.4.1 Active joint creation and dining enhance social interaction. The participants believe that interacting with food using *pic2eat* is a process of joint creation. P1 expressed, *"This creative process becomes our unique memory."* P5 noted, *"Choosing flavors is like adding a gustatory dimension to our work, and it can make us think about how to express more complex emotions."* Interestingly, compared to negative sketches and flavors, participants associated the taste of their appetizers to the experience they wished to have with their collaboration partner. Most participants prefer neutral and sweet tastes over bitter ones. P5 explained, *"No one likes to leave a bitter impression at the first meeting."* P2 also said, *"Sweetness brings a pleasant feeling to our first meet,"* and despite negative background prompts, P4 still said, *"Because I don't want to put you in danger and want you to come back safely, I think it's necessary to choose some sweet flavors."*

6.4.2 pic2eat offers a novel focus for social ice breaking. Participants generally find ice breaking through food interaction to be an interesting experience. P6 noted, *"3DFP became the main topic of our conversation."* Engaging with others through *pic2eat*, P3 pointed out, *"After receiving prompts, I focus more on our communication rather than just operating the app."*

6.4.3 Finding joy in the gap between anticipation and tangible experience. Most participants consider this a process of discovery. P1 stated, "Even though I have already chosen flavors for our painting, I am still curious about the final tastes." P5 shared, "It's like opening a mystery box; the unknown possibilities of food flavors bring a

sense of excitement." After tasting their creations, P6 frowned and commented: "Although I chose the sour flavor, the sourness of the Greek yogurt exceeded my imagination." But P6 also added for us: "But just like the appetizers we used to eat, maybe it doesn't need to be particularly delicious, as long as it can whet our appetite. Although the taste of this experiment is different from my imagination, but it also became a topic of conversation among us."

6.4.4 Make ice breaking more efficient. We also found that participants gradually get to know each other by asking questions. P3 mentioned, "I start by understanding the other person's preferences, for example, I might choose flavors they prefer," and they also decide whether to take initiative based on the other's personality. P4 added, *"I observe the other's choices to make better decisions."* Additionally, P5 said, *"This communication environment allows me to understand someone more accurately."* P5 also contrasted this with group icebreaking experiences, *"Group games enable quick understanding of the team, but getting to know an individual in depth is more difficult."*

According to Knapp's relational development model, we understand that social relationships can be established through brief exchanges [18]. *pic2eat* applies this theory by breaking down barriers in social relationships through food interaction technology. It enhances the ice-breaking process and fosters sharing and communication among participants by promoting a collective experience in exploring the visual and flavor of 3D printed food. Furthermore, food has unique potential in expressing emotions and conveying information in social settings. Viewing food ingredients as paint and rich flavors as a palette, *pic2eat* promotes interaction among participants through a collaborative and communal dining experience, helping them to establish or deepen social connections. As for the gap, in this experiment, we excessively focus on using different ingredients to distinguish various flavors. However, we acknowledge that there is still room for improvement in the development of the deliciousness of food ingredients.

7 CONCLUSION AND FUTURE WORK

In this study, we developed *pic2eat*—an innovative application that assists users in designing 3DFP appetizer through a collaborative drawing activity. This system aims to help strangers wishing to break the ice in social gatherings naturally establish connections by customizing the shape and flavor of 3D printed food based on random background prompts. However, the *pic2eat* project currently has some limitations. First is the restriction of food properties; in the future, we plan to explore a wider range of flavor combinations, not limited to the traditional sour, sweet, bitter, and spicy. Secondly, we hope to enrich the creative dimensions of 3D printed food by introducing more food properties such as texture and aroma. Additionally, there is still a space for improvement in the interaction system of *pic2eat*. For example, we believe that physiological information during social interactions, such as heartbeat, breathing, and emotions, provides an interesting channel to understand the authentic reactions of users in social settings. Therefore, in our future work, we plan to expand the interaction space between 3D printed food and users through the integration of hardware and software, aiming to offer a more natural and direct interactive experience. In conclusion, we hope that this work can support the HCI community in focusing on collaborative culinary efforts to enrich people's social engagement.

ACKNOWLEDGMENTS

We thank all the participants for their help. Florian 'Floyd' Mueller thanks the Australian Research Council, especially LP210200656.

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A APPENDICES

A.1 Participant information for Phase 1

Label	Occupation	Age	Culinary Experience
P1	Barista	37	15
P2	Dessert chef	29	11
P3	Baker	25	5
P4	Baker	26	6
P5	Graduate student	24	None
P6	Graduate Student	26	None
P7	PhD Student	28	None
P8	Undergraduate Student	23	None

A.2 Participant information for Phase 2

Label	Occupation	Age
P1	Staff	29
P2	Staff	27
P3	Staff	28
P4	Graduate Student	25
P5	PhD Student	28
P6	PhD Student	25

A.3 Preparation of 3DFP materials

Flavor	Approach
Tasteless	Two methods: 1. Peel 420g chickpeas, stir while heating, and gradually add hot milk, and finally use a masher until smooth and creamy; 2. Purchase hummus.
Sour	Buy Greek Yogurt in the supermarket.
Sweet	Add 120 g bread without crust (5 slices), a pinch of salt and 25g strawberry syrup, 50g hot water to a bowl and stir until there are no lumps. If the texture is too liquid, you may need to add more bread; if it is too solid, you can optionally add water or strawberry syrup.
Bitter	The method is the same as sweet, but you need to replace the strawberry syrup with boiled bitter melon juice and reduce the proportion of water.
Spicy	Same as above, but you need to replace the strawberry syrup with the chili sauce filtered by the strainer.

A.4 Prompts

Plex Card	Prompts
Captivation	A night sky filled with countless twinkling stars.
Challenge	A steep mountain peak challenging climbers.
Competition	A tense atmosphere at the starting line of a marathon.
Completion	A serene landscape after a long journey.
Control	A grand chessboard, with pieces positioned in a room.
Cruelty	A barren landscape with storm clouds.
Discovery	A hidden, lush valley bathed in the first light of sunrise.
Eroticism	A dimly lit room with soft, flowing fabrics.
Exploration	A dense, uncharted forest with beams of light.
Expression	A vibrant, chaotic artist's studio.
Fantasy	A surreal, floating island above the clouds.
Fellowship	A cozy, warm cabin with a glowing fireplace.
Humor	A lively carnival with bright colors.
Nurture	A serene garden with a nurturing and gentle atmosphere.
Relaxation	A tranquil beach at sunset, with soft sand and waves.
Sensation	A bustling city street at night, alive with neon lights.
Simulation	An intricate, blending reality and digital illusions.
Submission	A vast, orderly library, with endless rows of books.
Subversion	A graffiti-covered alley.
Suffering	A desolate battlefield after a storm.
Sympathy	A gentle, heartfelt reunion scene in a quiet park.
Thrill	A high-speed motorcycle race on a winding road.