From Plating to Tasting: Towards Understanding the Choreography of Computational Food

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Figure 1: Experiencing the computational food from plating to tasting.

ABSTRACT

The emerging concept of "computational food" focusing on the material affordances when designing food interactions is gaining traction in Human-Food Interaction (HFI). However, prior HFI research has not yet substantively investigated the dynamic nature of computational food from its creation to consumption, limiting our understanding of the complex interactions among creators, computational food, and consumers. In response, our paper shifts the perspective towards the dynamics of computational food interactions through a study in cooperation with chefs and gastronomists. Utilizing "Dancing Delicacies" as a research artifact – a system that facilitates dynamic dining trajectories – we adopted the concept of "choreography" to unravel the experiential dynamics of computational food. Our study resulted in six themes concerning computational food experiences and detailed four design implications central to culinary choreography. Our work aspires to leverage the choreographic potential of computational food design, paving the way for future HFI innovations.

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CCS CONCEPTS

• **Human-centered computing**; • **Interaction design**;

KEYWORDS

Computational food, Choreography, Human-Food Interaction, Food Design

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1 INTRODUCTION

A growing trend in HCI is the effort to "weave together" the digital and physical worlds [25, 32, 60] by emphasizing the materiality in the design of computational technology [55, 56, 59]. Such a "material concern" has given rise to the emerging concept of "computational food" that represents a future where food as a material is computationally transformable and reconfigurable [3, 27]. This concept leads to a broader research agenda reimagining food as a dynamic, interactive medium. It has motivated our investigation into food's computational potential, which could enable multiple future scenarios that move beyond a traditional view. Specifically,

we identify three potential benefits of computational food as key drivers of our investigation:

- *Enhanced personalization on the fly.* By leveraging computational capabilities, we envision the possibility that food can be dynamically reconfigured to align with changing consumer preferences and needs in real-time, allowing last-minute adjustments. This means that food is able to alter its taste for immediate gratification, modify its nutrient profiles to benefit health, or substitute its inner ingredients to comply with dietary restrictions or personal beliefs (e.g., wish to adhere to a vegan diet).
- *Improved distribution methods.* We envision computational food that can lead to novel, contactless serving in social dining settings. For instance, dishes could be programmed to self-serve according to individual requests, reducing the need for shared cutlery and promoting hygiene while still allowing the social aspect of sharing meals and engaging with fellow diners. This is particularly relevant in adapting to health sensitive circumstances, where minimizing physical contact is crucial.
- *Innovative culinary experiences.* We also envision that computational food can enable self-transforming dishes that offer sensory engagement and respond to diner interactions, such as changing shape in reaction to a diner's touch or actions. Such advancements could foster culinary creativity among chefs and provide diners with interactive and immersive dining experiences unlike any seen before.

Leading research initiatives have laid the foundational steps toward these envisioned culinary futures. Notably, works in "digital gastronomy" [9, 37, 62] have introduced methods for the "computability" of food, utilizing hybrid fabrication devices and generative algorithms to manipulate the flavor profiles and physical structures of food. These works primarily leveraged computational power to enhance food production, often disregarding the inherent qualities of food such as cooling, vaporizing, or decaying. The results typically presented static, unchangeable representations of computational processes – once produced, the food does not offer much interactivity beyond consumption. Moving beyond, researchers have experimented with dynamic transformations of food by regarding it as computational matter [53]. They have, for example, encoded active structures into food, enabling food items to transform their shapes in response to external stimuli during cooking [27, 58]. Similarly, prior research on "material integration" [12] introduced the design of a dessert as a computational artifact that is able to "compute" its own flavor and visual presentation through an intrinsic fluidic system [14]. Together, these prior works demonstrated the computability of food by employing food's materiality (i.e., changes of state) for the direct realization of a computational processes (i.e., taking in information, sense, and react), and simultaneously, using food's computational capabilities to achieve desired operations and effects (e.g., shape/color changes). However, many of those works have not emphasized the user experience, and those that did typically focused on either the chef's or the diner's perspective. Given that dining involves both chefs and diners, there is a gap in understanding the interactions between food creators, computational food, and consumers.

Extending the concept of computational food further, recent research demonstrated a novel computational food system, "Dancing Delicacies" [16], which could facilitate dynamic dining trajectories according to how the dishes were programmed by food creators and reconfigured by consumers. Through their design practice, the researchers proposed possible dynamics within the interactions between food creator, computational food, and consumer [16]. These dynamics prompted new relations to form due to the creative act of setting the conditions in computational food creation, enabling the emergence of new activities during consumption. We contend that these dynamics resonate with an expanded concept of "choreography", defined as "emerging, autonomous aesthetics concerned with the workings and governance of patterns, dynamics and ecologies" [28]. This concept of choreography encapsulates the creative process of setting the stage for new relationships to develop [28]. Unfortunately, we found a dearth of empirical knowledge regarding the influence of this choreography within computational food experiences. To address this gap, we utilized the concept of choreography as an analytical lens to investigate the dynamics of the computational food experience. We believe that this knowledge could deepen our understanding of computational food experiences and help illuminate the complex meanings underlying these interactions. This understanding could be vital for advancing the HFI field.

This paper reports on a study that builds on our prior design work called "Dancing Delicacies" [16]. Through engaging with both chefs (as food creators) and gastronomists (as consumers), we were able to unpack the emerging dynamics between food creator, computational food, and consumer by examining both creative processes and dining experiences with Dancing Delicacies.

Our work makes the following contributions:

- Groundwork for future design: We brought two new dishes to fruition out of six concepts. Both designs lay the groundwork for subsequent iterations of computational food, and expand the creative lexicon for future pursuits, especially via newly introduced ingredients, and could serve as a blueprint that highlights the culinary techniques compatible with the system.
- Thematic insights: We articulate six themes derived from our study's findings regarding the creation and consumption experience with computational food; these themes could guide HFI researchers to further investigate the multifaceted nature of computational food choreography from plating to tasing.
- Expanded dimension of choreography: We identify four new facets of choreography through a reflection on our themes. These facets offer fresh perspectives, enabling HCI researchers, especially those specializing in choreography, to explore new opportunities for choreographic interactions within the culinary realm.
- Design implications: We discuss potential design implications for the choreography of computational food in future culinary creations. These implications can guide food designers and culinary experts in the food and hospitality sector as they seek unique and captivating dining experiences.

2 RELATED WORKS

2.1 Building on prior understandings of computational food

The concept of "computational food" has initially envisioned food as a transformable and reconfigurable computational interface [3, 27]. Previous works have contributed to this concept, including research into shape-changing food [27, 58] and food-based electronics [12]. These associated innovations have enabled foods to function as sensors, actuators, and integrated circuits, as well as to serve as collocated input and output interfaces (hinting at a potential computing architecture) [10]. However, most previous works were predominantly focused on achieving a singular or rather fixed state of changes of the food materials, therefore affording limited interactions when it comes to the dining experience.

Recent research on the "Logic Bonbon" [12] aimed to change this situation by taking an experiential view on computational food. The authors presented a novel dessert that can "compute" its own flavor through integrated logic operations [14]. Using the dessert as a research artifact to investigate people's dining experience, this research provided a first account of the experience of consuming computational food. However, this dessert possessed only basic logic functions and offered predetermined interactivity with set inputs and outputs. The study has not yet deeply investigated the varied state changes of food nor the dynamics that emerge from people's interactions with computational food.

Taken together, there appears to be a noticeable gap in computational food design research into the rich diversity of people's food experiences regarding its dynamics. To delve deeper into the structures of computational food experiences, we articulate in the subsequent section a pertinent concept within the HCI domain that we believe could help enhance our understanding.

2.2 Learning from choreography and its relation to interaction design

The field of HCI has seen a growing trend in the arrangement and coordination of activities and events drawing together technologies and people into complex structures. The aim was to facilitate efficient and cohesive experiences that span across various temporal and spatial dimensions [6, 33, 44]. This trend has elevated the prominence of the "choreography" concept [11, 30, 61] within HCI research.

Choreography, traditionally associated with dancing and bodily movements in space and time [26] has been interpreted more broadly in recent research. Prior work [2, 18] has introduced and defined the concept of "choreographic interfaces" as human-computer interfaces that augment the "kinetic and spatial interactivity between humans and computers through integrating 'choreographic thinking' into the design process". These works described choreographic thinking as the "application of mental models derived from choreography to the understanding of movement, space, and time" [18]. Klien [28] proposed a modern take on choreography, defining it as the "interconnectedness" of all actions, encompassing the setting of conditions in creative processes for meaningful interactions, and the fostering of new relationships to appear among all participants [28]. This definition aligns with prior work that which regarded the choreography of interaction as "the total system of user, product, and other elements involved in interaction" [24]. Delving deeper, Parviainen et al. [40] described choreography as "all bodily movements and other activities in which movements appear to form meaningful interactions and relations between different animate or inanimate agents". Further elaborating on choreography's significance in interaction design, researchers have emphasized how design decisions influence actions and movements within the existing choreographies of specific situations [40]. For instance, Klooster et al. introduced a device named "Joint" [29], that demonstrated how designing a product can be an integral part of the choreography of interaction. This device fosters a choreographic play between two friends, allowing them to explore their relationship through touch and movement. This work showed that designing choreography of interaction incorporates more than just the product itself: it "embodies a trinity of physical involvement, dynamic quality, and expressed meaning" [29].

2.2.1 An analytical matrix of computational food choreography. Drawing on the insights above, we attempted to examine the value of "choreography" in HCI. We developed a 3-by-3 matrix of choreography with computational food by combining Derry et al.'s [17, 18] choreography models with Klooster et al.'s [29] three levels of examining human-technology choreographies (Figure 2). Our aim was to offer an initial comprehensive lens, not just for design, but also as an analytical tool that could illuminate the diverse facets of computational food choreography that might otherwise be overlooked. We hope that this matrix could help capture the entirety of the experience, encompassing physical artifacts and encompassing all users' actions across the whole interaction spectrum, from food creation to consumption.

Specifically, the matrix comprises two axes, each divided into three distinct categories, resulting in nine cells. Drawing from Derry's [17] concept of the "choreographic agency of user," our horizontal axis is labeled "agency of choreography". In our matrix, this axis identifies three potential agents of the choreography within the context of computational food interactions: the *creator*, the *computational food*, and the *consumer*. For our vertical axis, we adapted the three "pivots" of choreography as suggested by Klooster et al. [29]: *Physical Involvement, Dynamic Quality,* and *Expressed Meaning*. Below we tailored and expanded these concepts to fit the context and nuances of the computational food domain.

Physical involvement is concerned with who/what is physically involved in the choreography [29]. When applied to the domain of computational food interaction, *physical involvement* can be unpacked into three aspects. Firstly, it involves the creators who engage in cooking and plating activities. Secondly, it involves the food, with its inherent material affordances that offer possibilities and constraints to interact (such as the food's shape, size, construction, texture, color, and taste). Lastly, it encompasses the consumers and the various actions they undertake in the process of consuming the food.

Dynamic quality is rooted in the system's inherent capabilities and constraints. This pivot is concerned with space, time, and external force, highlighting how these factors interplay to produce the dynamism of interaction [29]. Within the context of computational

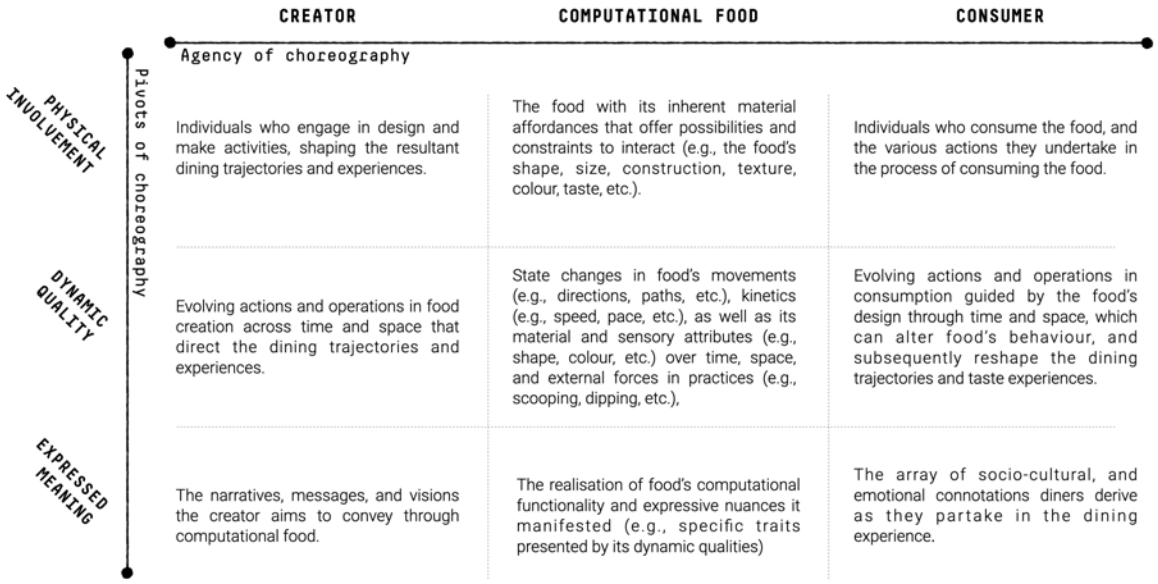

Figure 2: Matrix of computational food choreography.

food interaction, we unpacked the *dynamic quality* into three aspects: Firstly, from the creator's perspective, *dynamic quality* refers to their actions and operations evolving across time and space, which can potentially shape the dining trajectories and experiences. Secondly, viewing it from the food's aspect, the *dynamic quality* involves the state changes in food's physical movements (e.g., directions, paths), kinetics (e.g., speed, pace), as well as its material and sensory attributes (e.g., shape, color) over time, space, and in response to external forces during the food practices (e.g., scooping, dipping), facilitated by computational capabilities. Lastly, from the consumer's standpoint, it entails their actions and operations guided by the food's design through time and space.

Expressed meaning, according to Klooster et al. [29], emphasizes the choreographed meaning of interaction and involves all agents involved in an interactive unity. The concept highlights both functional meaning and broader social, emotional, and cultural connotations in the choreographic interactions. We unpacked this pivot into three perspectives. For the creator, it refers to the narratives, messages, and visions they aim to convey through computational food. For the food itself, it means the realization of its computational functionality and the expressive nuances it manifests (e.g., specific traits presented by its dynamic qualities). For the consumer, it captures the array of socio-cultural, and emotional connotations they derived as they partake in the dining experience.

Our matrix aims to provide an overview of choreography that provides a basis for the investigation of computational food experiences through the lens of choreography. We are particularly interested in understanding the role of food creators as choreographers who set the stage for events in a dynamic environment, and how the Dancing Delicacies dishes, as computational agents, carry out the performance while also guiding the diner's actions to foster engaging dining experiences.

In summary, our review of the prior concepts and associated works reveals a knowledge gap concerning the experience of computational food that could potentially be navigated via the concept of choreography. In this regard, this paper aims to answer the question: *How do we understand the choreography in computational food design and its impact on shaping food experiences?*

3 DANCING DELICACIES AS RESEARCH ARTIFACT

Our paper aims to investigate the computational food experience with a focus on choreography. By employing the Dancing Delicacies system [16] (Figure 3) as a research artifact, we can facilitate various dynamic dining trajectories via a set of food operations, such as moving food items, merging edible liquids, and blending multiple flavorings, that are governed by "electrowetting on dielectric (EWOD)" technology (the design process and technical details of the system has been reported in [16]). The system serves the purpose of a "research archetype" [36], that is, a "physical embodiment" of new concepts – the emerging dynamics within creator-food-consumer interactions enabled by dynamic trajectories with computational food.

This system can facilitate choreographic interactions by enabling a dish to be "programmable" and "reconfigurable". Specifically, through "programming", a creator can define the setting of the starting conditions of a dish and its dynamic behaviors (i.e., moving, merging, transporting), and through reconfiguring, a diner is offered several parameters to control the food process according to the settings defined by the creator (e.g., letting diners to control the dish's presentation or flavor combination). Figure 4 shows an exemplar dish that can facilitate a dining trajectory with multiple choices [16].

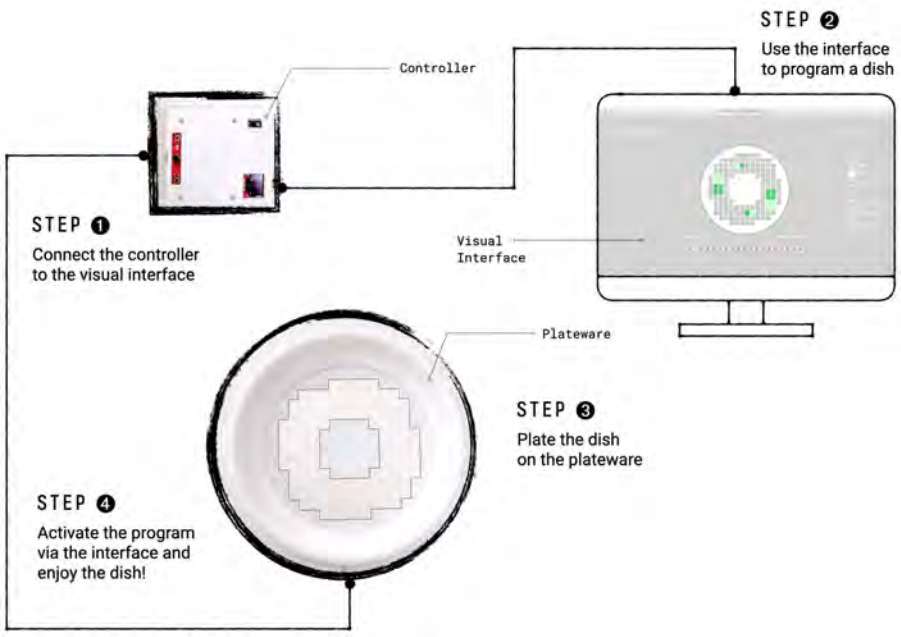

Figure 3: The Dancing Delicacies System.

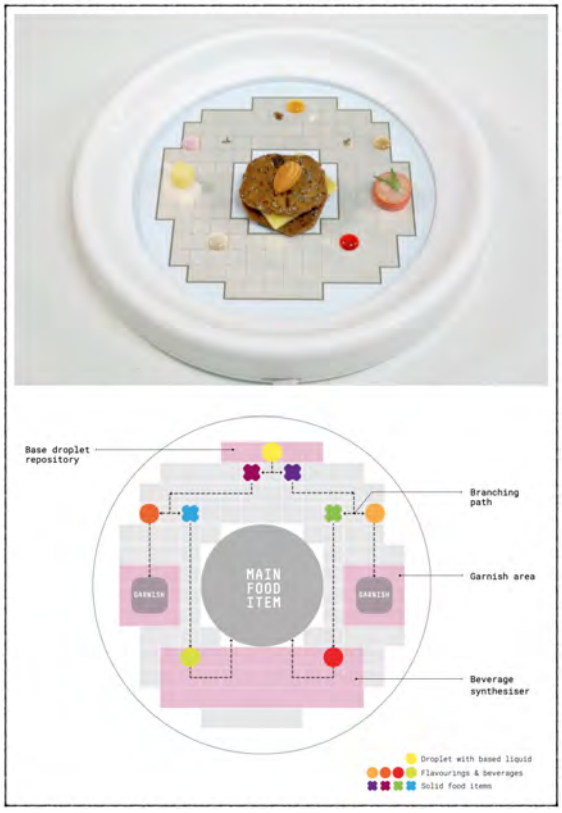

Figure 4: An exemplar Dancing Delicacies dish showing a multi-choice dining trajectory.

4 METHODOLOGY

In our study, we utilized the Dancing Delicacies system as a "research archetype" [36] to leverage the choreography in creator and consumer practices and interactions. We prioritized the involvement of participants with a deep ontological and epistemological understanding of food, as we believe such an understanding makes them more likely to draw better connections between food creation and consumption. Particularly, we established a space in which chefs and diners could engage, communicate, and express ideas. We intended for theses interactions to expand the potential for new understandings of choreography in computational food to emerge. Our two-phase study delved into the choreography of computational food, involving both experienced chefs and diners in the processes of "co-creation" and "dining experience".

4.1 Co-creation

The "co-creation" process is grounded in the "participatory design" tradition [23], which underpins the process of "investigating, understanding, reflecting upon, establishing, developing and supporting mutual learning" between multiple participants in a design process [23]. We see the process of creating computational food shaped around the involvement of food creators take over as an essential part of the evaluative phase of our study. The participants in this process, i.e., the chefs, are no longer the passive objects of a study, but rather, the person who is given the position of experts of their experience through the design process, and plays a role in knowledge development, idea generation and concept development [49, 57]. Through co-creation, we aimed to investigate how chefs as "choreographers" set the stage for the experiences to unfold dynamically throughout creative arrangements with reflective activities [52] in developing computational dishes.

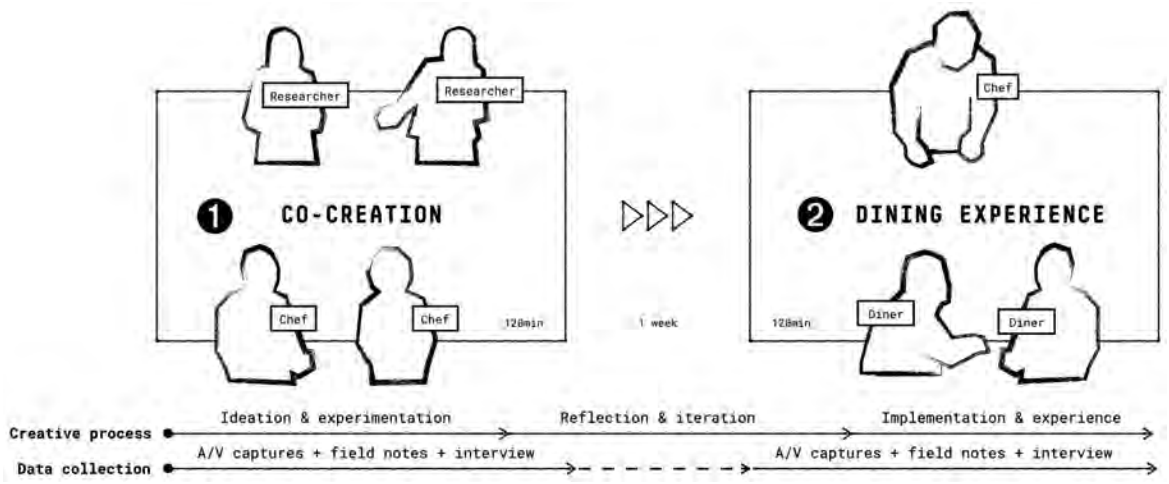

Figure 5: Schematic flow of the study.

4.2 Dining experience

The "dining experience" aligns with the "in-situ" concept in HCI [31, 45], which acknowledges that human actions and interactions are deeply "situated" [46]. While the approach emphasizes observing and engaging with participants in real-world settings [31, 45], it does not negate the importance of laboratory-based research [46]. Furthermore, current HFI studies [13, 15, 38] underline the significance of coordination and meaningful social interactions during food experiences [5, 14, 41, 54]. Therefore, in our dining experience sessions, we developed a simulated restaurant environment with an open-kitchen layout, aiming to encourage interactions and connectivity between chefs and diners, thus enriching the entire experience from food preparation to tasting in an authentic setting. It is important to note that our goal was not to mimic a high-end "fine dining" ambiance. Instead, we focused on creating a well-equipped and fully functional environment with a "cozy" dining atmosphere and effective risk management. This design aimed to ensure a smooth execution of the study, comfort for participants, and stringent food safety measures to mitigate any possible hazards.

5 STUDY

We conducted a study with both chefs (food creators) and gastronomists (consumers) with the objective of facilitating better computational food experiences through choreography that we found occurring during creator-computational food-consumer interactions (Figure 5).

5.1 Participants

We recruited 12 participants (age range 25–42 years, M=30.25, S.D.=5.36; 7 self-identified as male, 5 as female, none identifying as non-binary or providing other descriptions), comprising six chefs and six diners (Table 1). Participants were sourced from our internal lab mailing list, website advertisements, and word of mouth. When a potential participant expressed interest, one of our researchers initiated a pre-study conversation via Zoom to determine whether they met the selection criteria.

For chef participants, the selection criteria required them to: 1) have at least one year of experience in developing new recipes and directing food preparation for events or social situations; or 2) be currently employed in a restaurant, specializing in modern fusion cuisine and plating; and 3) be open to experiment with new technology that challenges traditional culinary methods. Given that most chefs may be unfamiliar with interactive technologies beyond standard kitchen facilities and equipment, we made concerted efforts to familiarize them with the Dancing Delicacies system before the study. This preparation included individual pre-consultations with chefs via Zoom, supplying them with instructional materials both text-based and visual, and providing a verbal briefing during the workshop.

For diner participants, the criteria included: 1) having an ardent interest in diverse food and tastes; and 2) exhibiting an enthusiasm for seeking out novel food experiences and a discerning appreciation of them.

5.2 Study procedure

5.2.1 Co-creation workshop. To facilitate the co-creation process of our study, we collaborated with six experienced chefs and organized three co-creation workshops [23], featuring two chefs in each workshop. These workshops drew upon "design thinking" principles tailored to food design [39, 48, 51]. To aid in the process, in each workshop session, two research team members supported the chefs by facilitating activities and providing worksheets, tools, and food materials for the ideation and implementation of new dish designs [47, 50] with the Dancing Delicacies system. The workshop, lasting 120 minutes, was structured through two tasks moving from divergent to convergent thinking (Figure 6).

Ideation & experimentation During the first task, chefs spent roughly 40 minutes brainstorming new dish concepts with "magical" qualities, inspired by the capabilities of computational food. Facilitated by our researchers, the chefs were provided with worksheets, visual aids, reference images, and sticky notes to stimulate out-of-the-box thinking. This activity aimed to detach the chefs

Table 1: Participants' demographics

ParticipantGroup	Code	Name(pseudo-nym)	Occupation	Experience of food-related practice	Past experience in food technology
Chef (Food creator)	C1	Chris (26, M)	Sous Chef	4 years' experience in local fine dining restaurant	Proficient with modern kitchen technology, no experience in digital technology
	C2	Rich (30, M)	Casual chef /Cooking enthusiast	Culinary content creator on YouTube, grounded in a decade of family cooking traditions	Skilled in interactive device design and development, with passing knowledge of modern kitchen technology
	C3	Mitch (42, M)	Head Chef	24 years' experience in global restaurants	Proficient with modern kitchen technology, knowledgeable about digital technology innovations in the food industry
	C4	Blake (38, M)	Head Chef	12 years' experience in global restaurants	Moderate experience in using modern kitchen technology, no experience in digital technology
	C5	Dominic (36, M)	Head Chef	17 years' experience in local restaurants	Moderate experience in using modern kitchen technology, no experience in digital technology
	C6	Nick (31, M)	Head Chef	4 years' experience in local restaurants	Moderate experience in using modern kitchen technology, no experience in digital technology
Diner (Consumer)	D1	Dan (28, F)	Researcher	Consider themselves an adventurer who is keen on novel food experiences	Moderate experience in using modern kitchen technology, no experience in digital technology
	D2	Pat (30, F)	Researcher	PhD in digital health with an emphasis on eating disorder studies	No hands-on experience but well-informed about digital technology in the food industry
	D3	Nadine (25, F)	Coffee Technician	5 years' experience in the hospitality industry	Extensive experience in studying and using digital equipment and appliances in industry practices
	D4	Phoebe (26, F)	Masters Student	Consider themselves an adventurer who is keen on novel food experiences	No hands-on experience and passing knowledge about digital technology in the food industry
	D5	Chad (26, M)	Researcher	Consider themselves an adventurer who is keen on novel food experiences	No hands-on experience but well-informed about digital technology in the food industry
	D6	Zelda (25, F)	Researcher	Consider themselves an adventurer who is keen on novel food experiences	No hands-on experience and passing knowledge about digital technology in the food industry

from traditional practices, encourage expansive thinking, and develop a collective understanding of the context and potential of computational food.

In the second task, lasting around 50 minutes, each chef developed a Dancing Delicacies dish under specific system constraints and parameters outlined on their worksheets. These constraints were primarily due to the system's limitation to aqueous droplets and restricted droplet movements [16]. Despite these constraints, chefs were encouraged to experiment with parameters such as the kinetics (i.e., velocity and pace), expression (i.e., emotion and traits), and operation (i.e., mix and transport). They were also supplied with an array of food materials and ingredients for hands-on experimentation. These materials were not necessarily intended for use in their final dishes but were provided as concrete tools to aid in demonstrating their design concepts. Upon completion, the initial dishes were presented for discussion, allowing chefs to share their concept, the anticipated taste profiles, and their choreography of the diners' experience.

After finishing the ideation, we ran a group interview [20] (approx. 30 minutes) with the chefs at the end of each workshop. The interview sought to stimulate discussions by asking topical questions in a semi-structured manner [1], using the laddering technique [42]. Questions included: "in what ways did the Dancing

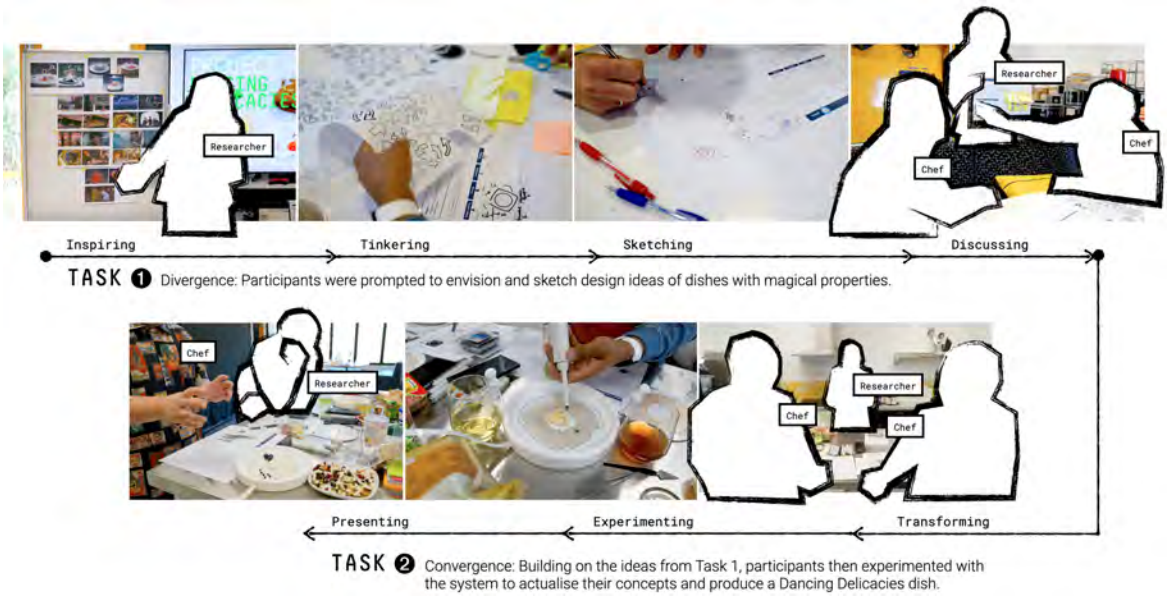

Figure 6: The process of co-creation workshop.

Delicacies system enhance/hinder the way you conceive and design a dish?"; "how did the 'computation' change the way you realized the intended experience from the dish?"; and "how did you consider taking more/less control over the ways that your diners consume the dish as how it was being designed?"

Reflection, iteration & & implementation After the workshop, chefs who expressed an interest in progressing their ideas to the next phase were tasked with reflecting on and refining their design concepts. They were instructed to prepare the ingredients for the subsequent phase of our study, which was scheduled during the subsequent weeks. Throughout this interim period, our research team maintained regular communication with the chefs through emails and online meetings. The chefs were encouraged to visit the lab kitchen to test their recipes and further refine their designs under the supervision and guidance of our researchers. Once this iterative process was complete, we scheduled a dining experience session with the chefs to implement the final dish and serve it to the diners.

5.2.2 Dining experience session. We conducted three dining experience sessions with six diner participants to experience the dishes in our dedicated lab kitchen. The kitchen was presented in an open kitchen style that would facilitate the chef making the dish in front of the dining table and communicating with the diners. Each session included two diners, and one chef from the co-creation workshops prepared their dish. The session was structured into three phases: pre-dining, dining, and post-dining.

Pre-dining During the pre-dining phase (approx. 45 minutes), the chef began preparing the ingredients according to their final designs and set up the dining table with help from our researchers if needed.

In-dining During the dining phase (approx. 45 minutes), the diners entered and were guided to sit down. When the diners were settled, the chef started to introduce the dish including its concept and philosophy behind it, and to showcase all ingredients while they worked in front of the diners. Both the chef and the diners were encouraged to talk freely and ask questions. When the dish was plated and served, the chef started to initiate the execution of the pre-programmed operations of the dish, so that the food items on the plate could dynamically move and re-organize as intended. The diners were invited to interact with the dish as they wished. Figure 7 showcases the dish in one of our dining experience sessions.

Post-dining During the post-dining phase (approx. 30 minutes), both the chef and diners from the same session were invited to an interview on their experience with the dish. They were asked topical questions, such as: "how did your experience change over time?"; "how did you feel about having more/less control over the dish compared with the traditional way of creating/eating the dish?"; and "how did it make you feel about the relationship between you and the chef, the diners, or the food?".

5.3 Data collection and analysis

Our data set included video and audio recordings from all workshops and dining experience sessions, capturing conversations, activities, and group interviews. We transcribed the video and audio recordings of the discussions and interviews that were most pertinent to our research question. To ensure privacy, all transcriptions were anonymized, and participants were assigned pseudonyms. Furthermore, we collected field notes and reflections penned down on the participants' worksheets during the co-creation workshops, and we documented the design outcomes (section 5.4).

We used NVivo to code the data using a hybrid approach including both deductive and inductive coding based on the tenets of social phenomenology [19]. The deductive codes were identified based on a practice-informed conceptual framework from the

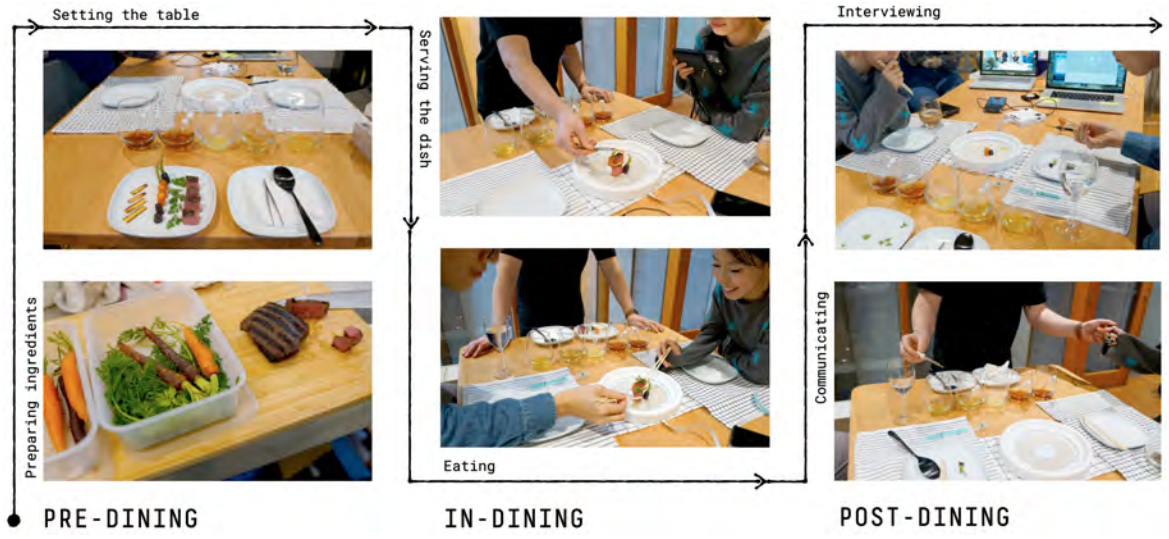

Figure 7: Flowchart of the dining experience session.

Table 2: Two Dancing Delicacies dishes spotlight the concepts, ingredients and techniques used in their creation.

	Dish #1: Yin & Yang	Dish #2: A Taste Ballet
Chef	Chris	Mitch
Description	Yin & Yang features black and white sauces gradually merging, complementing the final dish.	A Taste Ballet features various flavorings performing a ballet dance towards the center food items.
Concept	*"This dish represents the opposite but interconnected forces, like 'Yin & Yang', that slowly creates itself out of chaos, and self-organizes into balance and harmony, as symbolism of the life cycle."* (Chris)	*"This dish, inspired by my daughter who's a ballet dancer, combines ingredients harmoniously from the farmland and soil. The flavors, elegantly intertwined with a unique rhythm, perform a ballet on the palate, building to a crescendo that culminates in a rich, delightful finale."* (Mitch)
Recipe	Flavoring droplets: Squid ink, katsuobushi black vinegar, soy sauce; diluted buttermilk with yuzu Bites: Kombu cured flathead fish, eggplant, mint flower, sesame cracker	Flavoring (droplets): Five sous vide extracts (carrot, rosemary, thyme, orange flesh and orange zest), temperature set at 52℃, time set for 12 hours. Bites: Beef steak, rainbow carrots, cilantro
Dining session	Session 1, Session 2	Session 3

previous work on designing the Dancing Delicacies system [16], a theory-informed through prior research [29, 40] and our matrix of choreography (section 2). Five provisional codes emerged, including *material affordance*, *dining trajectory*, *chef-diner connection*, *human-food synergy*, and *sense of agency*. Lastly, using reflexive thematic analysis [8], six themes were iteratively refined during discussions between the two authors (section 5.5).

5.4 Co-creation outcomes

From our co-creation workshops, we distilled two key outcomes:

- We derived six conceptual designs of the Dancing Delicacies dishes (Figure 8). These designs could lay the groundwork for subsequent iterations of the dish designs and possibly expanded the creative lexicon for future innovations in computational food.
- From the six conceptual designs, we brought two dishes to fruition (Figure 9). Both dishes underwent refinement before being presented in our dining experience study sessions. This exercise introduced new ingredients to the existing food material library, building upon previous research [16], and laid down a blueprint highlighting the culinary techniques compatible with the system. As shown in Table 2, we introduced new liquid ingredients to the system, such as seasoned squid ink and diluted flavored buttermilk. We also adopted the sous vide technique to obtain natural water-based food extracts that expanded our ingredient list and enriched the taste spectrum available for computational food creations.

5.5 Findings

We clustered our study findings into six themes relating to the choreography of computational food.

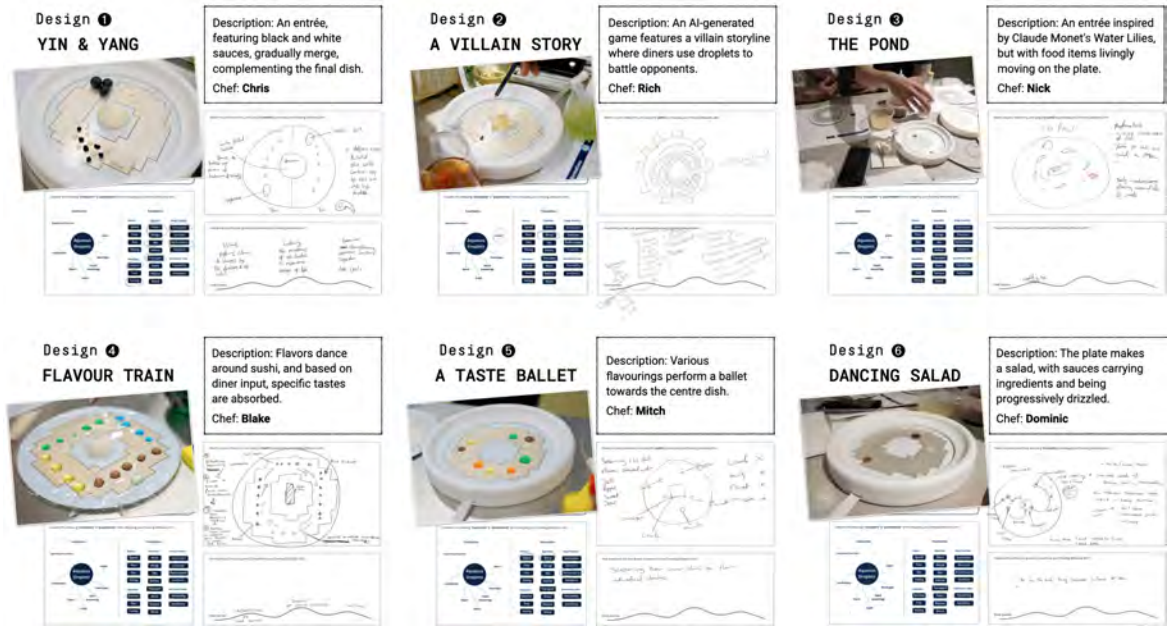

Figure 8: Conceptual dish designs.

Figure 9: A showcase of the two dishes implemented for the dining experience study sessions.

5.5.1 Theme 1: Expressiveness through thematic anchors in culinary conceptualization. From our observations and interviews with chefs, a distinct theme-based approach emerged when they were conceptualizing new dishes using the Dancing Delicacies system. In contrast with traditional hospitality settings where dish development often pivots on established culinary norms, taste profiles, ingredient availability, commercial concerns, and directives from higher-ups, the Dancing Delicacies system seems to inspire chefs to prioritize thematic anchors. Blake (C4) illustrated traditional constraints, mentioning factors like seasonality and costs that dictate dish creation. Blake (C4) shared:

"As chefs in a commercial setting, what you do is in the morning you are given, [. . .e.g.,] 'uh, oranges are in season and supplier has a good quality, do something with oranges' [. . .] I think cost has [also played] a big factor. Not necessarily because you want to do it, but you are given those constraints."

However, with Dancing Delicacies, chefs like Chris (C1), Dominic (C6), and Nick (C5) highlighted a starting point rooted in aesthetics and the system's design, emphasizing the unique structural constraints. Chefs also expressed that, even before selecting ingredients, they already envisioned the thematic imagery they aimed to create. Like Chris (C1) described:

"What came to the first is the, really weird, like, the concept. The starting point was actually the whole aesthetics [of] the plate [system] itself, it has its own structure and constraints. So, I had the vision of the image that I wanted to do, like the shape and everything, and started from that, I think about whether I want to put a bit of a theme on it, I then go think about my ingredients."

Mitch's (C3) ideation behind "A Taste Ballet" offers an insight into the intertwining of personal experiences with culinary creativity. The core theme of "dance", characterized by the food items' motions, evoked memories of his daughter's ballet performances. This connection inspired a broader theme of "harmony", influencing not just the choice of ingredients but also the taste balance and rhythm of the dish. Nick's (C6) ideation process seemed to resonate with Mitch's:

"It's [the dish] called 'The Pond'. The way I see it [the plateware], it's like a basin [. . .] And I went to the Monet exhibition the other day [specifically referring to Claude Monet's series paintings of the water lily pond], the way I see this is more of a theater. You get to put a show on before you start eating. I want something like little lily, nasturtium leaves, like herbs and salads around, and then droplets can act as fishes swimming around the main dish. The dish tells a story about the painting and the artist, it could be a kind of Impressionism-themed experience."

This theme suggests that computational food can bring about a shift in the creative process chefs typically employ. The design and computational capabilities of the system can play a significant role in the dish creation process. Furthermore, we found that personal experiences can also serve as foundational pillars in the creation of such thematic dishes, emphasizing the deep human connection inherent in computational food creations. This can add a layer of intimacy and relatability to the dining experience.

5.5.2 Theme 2: Curated experiential potentiality over culinary instrumentality. This theme highlights that while chefs tended to feel that the system might limit their daily kitchen practices and tasks, due to its technological constraints, it simultaneously encouraged greater exploration of food's experiential possibilities during the creative process. Specifically, from a practical standpoint, Chris (C1) and Dominic (C5) shared their opinions on the "extra efforts" required, such as applying ingredients with aqueous qualities, and the time they had invested in continuously learning, experimenting, and programming the system:

"There's definitely extra effort, for the [food] product itself, for cooking itself, it gives you a lot more limitations for the things that don't necessarily have to be done this way [. . .] lots of these [making procedures] actually take longer, and it's not something you can achieve instantly on the plate in a short time." (C1)

"I think this [system] for me, acts more as a perimeter to work within, rather than an extension of what I can do. It restricts what I can typically do on a normal plate." (C5)

Nevertheless, chefs appreciated how the system shifted their focus towards crafting an experience rather than just perfecting the final dish presentation. Rich (C2) explained:

"It has its limits, but it also brought out a very interesting side of food, you can be more interactive telling a better story, a better story."

Moreover, after having the experience with diners together, chef Chris (C1) emphasized the importance of crafting an experience, he shared:

"My feeling about the whole process, like it's not really about how the food should taste or whatever. It's like we're trying to figure out if we can actually create an experience rather than just give you something to taste [. . .] For me, it's like we are in search of the potential of another dimension of experience rather than any certain type of food I reckon [. . .], and you want to try to create more on the experience side rather than the dish itself".

In essence, this theme suggests chefs intended to prioritize the experiential side of dining over the mere presentation or taste of the dish when creating computational food. Furthermore, such an intent can position the chefs not just as culinary experts but as choreographers of a rich experience. This might facilitate movements where chefs and restaurateurs seek to differentiate themselves by offering unique, experiential dining rather than just gourmet meals.

5.5.3 Theme 3: Unraveling underlying narratives through food's dynamism. This theme highlights an active, energetic process of when chefs encode a dish's concept, and when diners understand the dish's philosophy that a chef wants to convey. Chefs valued how the dynamic nature of computational food broadened their mindset and enhanced their design intentions to effectively convey their concept to diners. Chris (C1) acknowledged that this dynamism not only sparked his concept of "Yin & Yang" but also seamlessly integrated with this concept. He elaborated:

"And also, like what we did [a trial run with the system] before, it [blending black and white sauces] actually formed a shape of Yin & Yang. When I saw it on this platform, I immediately knew it's gonna be more of a themed thing already. So, giving it [the dish] a bit more overwhelming concept won't be so overwhelming in this case [. . .] And it makes sense of the concept as well."

This opinion was further affirmed by the diners. For example, Dan (D1) stated that the dynamic movements within the dish played an essential role in her interpreting and understanding the dish's underlying concept of the dish:

"When we actually saw the process of mixing the white and black sauces, I kind of get the point why it is called Yin & Yang, and where the name comes from."

Zelda also expressed her thoughts on the food's dynamism and expressed meaning as:

"I really appreciate not just how delicious it tastes, but also the thoughts and meanings you [referring to C3] put in each ingredient. Like how you took inspiration from your daughter's ballet and how the carrot symbolizes soil while other ingredients represent the land [. . .] Everything came together like a collage, where different components and flavors came to achieve balance. The movement embodies harmony, adding more meaning to the flavors."

The theme underscores the active process of conceptually conveying and understanding a chef's philosophy through computational food. The dynamism is found not only in the physical aspects of the dish but also in the thought process behind the dish. It appears that computational food could encourage chefs to experiment with and employ unexpected dynamic presentations. Essentially, the dynamism brought by computational food could serve as both an enhancer of chefs' creativity and as a bridge to a more insightful and meaningful dining experience for the diners.

5.5.4 Theme 4: Chef-food synergy via dish's performance. While studying the interplay between the creator, computational food, and the consumer during dining sessions, we noted a unique synergy between chefs and computational food. This theme explores how computational food can collaboratively participate with chefs in the plating and serving process. This process marks a departure from the conventional open-kitchen dining style where the chef singularly dominates the food performance and presentation. Chris (C1) elaborated:

"An interesting point with Dancing Delicacies is that it actually takes part of the performance now. It shifts the diners' attention to the dish rather than the chef himself. It's [the computational food] a good tool to center the diners' focus on the dish's presentation and implementation, rather than, you know, wondering about the chef: 'What is he doing?' 'What's the chef chopping now?' 'Oh, he's putting that thing on top of that thing. . .Oh no!'. . ."

Furthermore, chefs found themselves less burdened with the task of explicating the intricacies of a dish. As it is artistically plated, crafted, and animated, the dish takes on the tasks of both performer and narrator, eloquently presenting its complex elements to the diners on the chefs' behalf. Such "working together" between chefs and computational food also heightened the diners' awareness of a dish's complexity, which appeared to enrich their dining experience. This view is echoed by Zelda (D6) who remarked:

"I noticed the complexity of the dish. It's not like I usually think, like in the restaurant, when we are having a dish, I was not aware about all those thoughts and different layers, different ingredients it has. But seeing the process of different aspects or elements of the dishes, like moving towards each other, made me be more aware of the complexity of the dish, and I think even when I was tasting it, that awareness also brings more appreciation and more richness to the dish itself."

This theme suggests that, unlike the conventional open-kitchen style that centers on the chef's performance, computational food plays a collaborative and active role in the dish's presentation and performance, captivating diners via its evolving presentation. The synergy between the chef and the food they create can be seen as a form of choreography, where both elements come together to deliver a performance that is captivating, meaningful, and evocative. This dish-centric approach can not only reduce the explanatory burden on chefs, but also enrich the dining experience, as diners connect the highly visual choreography with the flavors, which leads to a heightened awareness and understanding of the dish's complexity.

5.5.5 Theme 5: Animated dishes fosters anthropomorphic interactions. This theme shows the participants' (chefs and diners) inclinations to view the food items as living, anthropomorphic agents. Participants attributed human-like feelings or traits to the computational food when they interacted with it. For instance, Rich (C2) presented a dining concept whereby diners interacted with food droplets that took on the roles of heroes and villains in a series of flavorful encounters (Figure 8, Design 2). Many diners instinctively perceived these animated food items as possessing a life-like quality and distinct personalities. Conversations reflecting this sentiment included:

Pat (D2): "It [moving food items] looked like a living organism, like some sort of biotic thing."

Dan (D1): "Kind of like the Venom [movie] when the black [sauce] went to the white ones, and then went right straight into the food."

Also, there were dialogues between diners and chefs:

Nadine (D3): "It seems that the black liquid underneath [the fish] is moving that way [referring to the sauce trying to get rid of the fish] on their own."

Chris (C1): "It's like 'let me out!' [laughter]"

Chad (D5): "Some [food droplets] moved together and then they incorporated being soaked by the steak. But while the others, they just run away. They didn't want to be soaked. . ."

Mitch (C4): "That's the black sheep of the family! [laughter]"

Zelda (D6) further commented on the anthropomorphic nature of the interaction; as if the food items held their own intent and purpose, performing as if they were on a stage:

"Watching the sauce move towards the food felt like a beautiful metaphor for encounters. It's as if the ingredients themselves have their own agency in how they interact and meet [. . .] The food items felt as if they embodied unique characters and personalities, there seemed to be a storyline and emotion behind each droplet's movement; it seemed the droplets hesitated to approach the meat, as if they were shy."

We discovered that such anthropomorphism enhanced the interactions and connections between diners and the dish, especially when the food droplets did not execute as programmed (e.g., got pinned on the plate) due to unpredictable material qualities (i.e., inconsistent viscosity of the food droplets). As the diners commented:

Chad (D5): "Even though something went wrong, it showed some sort of a personality. So, it makes me feel [the dish was] more like a human and say, more interesting."

Zelda (D6): "I felt more connected because there was a 'glitch', it's something that happened wasn't being planned. This made it seem as if the dish had its own thoughts, like maybe they [the food droplets] are unwilling to cooperate. Maybe they were lost or needed some help. As a response to that, I got my intention to interact with them, like helping them out, and it made me feel more connected to 'who they are' [. . .] and this also brought more appreciation and more richness to the dish itself."

This theme suggests both chefs and diners could perceive food beyond its traditional role as sustenance, recognizing it as an entity with its own narrative, emotions, and intentions. By anthropomorphizing food items, the culinary presentation could become not just about taste but also about the underlying traits and emotions each dish expresses and evokes. As a result of such anthropomorphic interactions, diners can become deeply invested and engaged in the food's animated behaviors, heightening their appreciation of the culinary craft.

5.5.6 Theme 6: A culinary bridge reinforces chef-diner bonds. This theme illustrates the potential for computational food to serve as a culinary bridge that can reinforce chef-diner bonds. Our study found that these bonds often arise from the unexpected, serendipitous events that occur during culinary creation. These moments of unpredictability in computational food interactions can lead to inventive collaborations and deepen the emotional ties between chef and diner.

Specifically, those spontaneous events are not necessarily seen as obstacles, but rather embraced as chances to explore new tastes and presentations, reminiscent of the unscripted movements in dance that bring joy and beauty. Chris (C1) viewed the blending of the black and white sauces, which formed an exact but unforeseen Yin & Yang pattern, as a serendipitous inspiration:

"Actually, the mixing sauce part is like just coming on the fly, that was something more inspiring, like something that happens randomly, but can still work our way around it."

Our study also suggested that an unexpected challenge can turn into a collaborative opportunity. For example, when some food droplets became stuck on the plate, both the chef and diners instinctively collaborated to interfere with the process: the chef introduced more flavorings to connect them with other moving droplets, while diners used cutlery to guide these droplets to their intended destinations. Participants likened these unforeseen incidents to spontaneous improvisations seen in dance performances, bringing new opportunities for taste adventures thanks to the unexpected events. The following exchange between diners echoes this perspective:

Chad (D5): "One thing I do notice is, because of the accident, we didn't get every flavor mixed together with the steak. So, I just tasted part of the [sauce] separately and waited to try other flavors later. It made me feel like I do have other kinds of combinations. Even now, I feel it's a good thing that I could try this flavor first and then I could try that one later."

Zelda (D6): "And also like for me, I'm also practicing dancing. I feel when the movement of drops somehow went the way that was not as planned, it's also beautiful, like Chad (D5) said like how it could bring up different possibilities."

Furthermore, the unveiled chef's vision and narrative, and the immersion into the chef's world, allowed the diners to feel an intimate connection with the chef without having to speak. Phoebe (D4) reflected:

"You felt a bit more a part of the entire team of creation. I feel like getting involved in something when came up with that scene [referring to participating in the plating together at the beginning], it's kind of you feel a bit closer to its creator, you kind of know a bit more about them and you don't have to talk to them, that's fine, coz you just know them through the food."

This theme highlights a dynamic culinary landscape where unexpected elements in computational food interactions can be embraced as creative improvisations. It can transform dining into a collaborative and enjoyable journey with open-ended experiences and varied outcomes. Those evolving changes and emerging uncertainties along the journey can encourage diners and chefs to explore and celebrate a broad spectrum of tastes and presentations, while also facilitating the exchange of cultural knowledge between them [35]. This contrasts with traditional open-kitchen styles, where chefs typically lead while diners remain mostly passive observers. Here, the dynamic is shifted, creating a stronger bond between diner and chef. Diners become active contributors to the culinary story, deepening their appreciation for the culinary arts and potentially fostering greater loyalty to specific chefs or dining establishments.

6 DISCUSSION

6.1 Critical reflections on the challenges in culinary practices

We discuss potential limitations that our themes might impose on chefs' creativity and culinary processes, which could in turn impact the diners' experiences. We outlined the benefits in the above themes, such as enabling chefs to artistically express themselves and stimulate creativity with computational power. These advantages can strengthen the bond between chefs, diners, and their culinary creations, potentially enhancing customer satisfaction and loyalty, and opening new business opportunities in the food and entertainment sectors.

While the benefits of computational food are significant, they come with challenges. A prominent obstacle, noted in theme 2, involves technological constraints that limit chefs to aqueous ingredients and specific methods, which diverges from conventional restaurant practices and challenges the norms of daily kitchen operations. Moreover, chefs have also expressed concerns about the learning curve associated with these systems, including acquiring computational skills, investing time in ingredient preparation, and experimenting with the new system, which could be daunting for those less familiar with technology, possibly hindering innovation in the kitchen. Furthermore, the chef-food synergy, as highlighted in themes 4, could lead to concerns about diminished creative control, with chefs feeling their autonomy is reduced as the food's self-operating nature might reduce their ability to intervene and guarantee the quality of their creations, especially during unexpected events (theme 6). This situation leads to an additional challenge for chefs – determining the appropriate level of control to delegate to diners. It is crucial to strike a balance that offers diners sufficient freedom and engagement in the experience, while avoiding overcomplication and overwhelming them with too many parameters and interactions. Lastly, the extra costs associated with these technologies could upset the balance of cost and performance ratio in traditional restaurants and food retail businesses.

6.2 Facets of computational food choreography and design implications

In the following section, we identify four salient facets underpinning computational food choreography, drawing upon our study results: *unforeseeable culinary improvisation*, *anthropomorphized gastronomic expression*, *collaborative interplay*, and *material narrative of culinary artifact*. These facets further extended the "pivots" of choreographic interaction within our matrix in section 2. Within each facet, we discuss our findings with a focus on their design implications for future HFI designs, aiming to provide guidance for scholars and practitioners interested in studying and crafting choreography in computational food experiences.

6.2.1 Unforeseeable culinary improvisation. Our study results suggest that culinary choreography can exhibit an unforeseeable nature. In particular, we noticed that varied food viscosities and inconsistency can result in unforeseeable movements, such as the emergence of spontaneous patterns and motions by food droplets that cannot be programmed. For instance, we observed unanticipated Yin & Yang patterns (themes 3, 6) and dragging motions when droplets were anchored on the plate (theme 5). These seemingly "glitchy" behaviors were not necessarily impacting the experience negatively. We noticed that this unforeseeability could prompt instinctive actions where chefs interfered by adding flavors to engage with those pinned droplets, while diners disrupted by maneuvering them with cutlery, seemingly assisting them to move to their intended location. This unforeseeable dynamic seemed to amplify diners' immersion and potentially even deepen their food appreciation as they were able to participate in the crafting process, investing in the process that led to the final dish.

Design implication: Harnessing the unforeseeable culinary improvisations to amplify food appreciation

The above highlights potential avenues for designers to purposefully employ unpredictable food movements to foster improvisational engagement. Particularly, integrating seemingly "glitchy" moments or introducing deliberate challenges during dining might lead to serendipitous taste discoveries and, potentially, a deeper appreciation of the food.

This approach aligns with existing HCI theories. First, Gaver et. al. [21] advocated the merit of "ambiguity" in interaction design, suggesting that unforeseeable elements render a "mysterious and thus attractive" system that can compel people to join in the work of making sense of it. Furthermore, the idea of introducing deliberate challenges aligns with Andersen et. al.'s [4] argument of the potential of disruptive improvisation, which uses concepts like "scarcity", "uselessness", and "failure", to "make the familiar strange", or "creatively problematize to promote innovation". However, a challenge lies in balancing between unforeseeability and the requisite planning [7, 34]. Therefore, culinary creators should strike a harmonious balance between improvisational adaptability and scripted choreography.

6.2.2 Anthropomorphized gastronomic expression. Our study highlighted that food droplets, when animated, can exude lifelike characteristics, prompting both chefs and diners to interpret them as living, anthropomorphic entities (theme 5). The rhythmic and dynamic behaviors exhibited by these droplets were reminiscent of certain emotions or traits, such as vulnerability or shyness. Some diners showed empathetic actions, guiding the "stuck" droplets back to their intended paths. We noted that such anthropomorphic cues fostered deeper emotional bonds, and potentially created a sense of unity and camaraderie with the food.

Design implication: Crafting anthropomorphized food interactions to cultivate deep human-food affinities

The above insights suggest that by deliberately embedding human-like traits into food movements, creators can amplify the expressiveness and deepen the emotional ties diners have with their dishes. Through precise programming, creators can manipulate kinetic parameters of food, such as pace (e.g., the rate of food droplets are blending), speed (i.e., how fast the droplets are moving), or paths (e.g., the direction the foods move along), to evoke varied emotional associations in diners.

This anthropomorphized approach aligns with prior HCI research on shape-changing interfaces that proposed "expressive parameters" based on kinetic attributes, drawing out specific traits and qualities from certain movements [43]. For instance, rapid oscillating movements might be reminiscent of "agitation" or "enthusiasm" [43]. This implication also connects with the future direction of HFI that calls for anthropomorphized food interactions, intending to bolster customer loyalty by establishing an emotional bond between diners and food items [15]. However, a critical challenge lies in ensuring that the designed expressiveness aligns with the user's perception and the creator's intent. Therefore, culinary innovators should carefully test and refine these traits to ensure the desired experiences are achieved.

6.2.3 Collaborative interplay. Our investigation unveiled a collaborative nature between chefs, computational food, and diners, as evident in themes like "chef-food synergy," and "chef-diner bonds" (themes 4 and 6). This collaborative interplay highlights the collective feature of culinary choreography, rendering it not merely as a spectacle but as a cooperative experience. This feature was facilitated by the system that was designed to function as stages, exuding expressive appeal (e.g., synchronized food performances that echo the chef's crafting process) and visual cues (e.g., moving droplets provoke actions). Our insights highlight that the culinary experience is not a solitary act but a collaborative endeavor. Chefs and diners both play roles in shaping the experience. In our study, the chefs set the stage, while diners were not merely passive recipients of the chef's creation, but they took part in an explorative tasting journey through their reactions and interactions. This collaborative choreography appeared to foster a more adventurous and experimental tasting experience.

Design implication: Harnessing the collaborative interplay for a shared explorative food journey

We recommend culinary practitioners to incorporate the specific moments and perceivable control events that invite both chefs and diners to take a part in the culinary journey, and to foster an inclusive space for this shared culinary choreography.

This speaks to Benford et al.'s [6] concept of "trajectories". The authors proposed the trajectory concept to map out structured user experiences, accentuating the multiplicity of roles in any interaction. This posits a dichotomy: the trajectory that a designer envisions versus the trajectory taken by the end-user [6]. To solve this, it needs designers to engage in behind-the-scenes activities—managing, monitoring, and making timely interventions. Our study builds upon this view by casting chefs as both choreographers who is not only manage the food from the sidelines, but also participants who dynamically steer emerging experiences. Simultaneously, diners are empowered not just as spectators, but also have the agency to take part in modifying what is being partially pre-determined. With the anthropomorphic traits of computational food, we see a triumvirate dance of the food creator, food, and consumer, each playing a pivotal role in the overall choreography.

6.2.4 Material narrative of culinary artifact. Our findings also demonstrated that the inherent aesthetics of the artifact's design (the Dancing Delicacies system) can serve as a blank canvas, inspiring thematic anchors and allowing creators to intertwine personal narratives, memories, and experiences (theme 1, 2). The emphasis here is on the materiality of the artifact as an integral component of culinary choreography. For example, the plateware design of the Dancing Delicacies system, both structurally and functionally, served as an impactful storytelling device. Culinary creators can thus draw upon the aesthetic language of the plateware (e.g., its smooth shape, subtle edge, and soft white hue), marrying it with personal experiences to curate their dishes that champion expressiveness and narrative-driven designs.

Design implication: Leveraging the artifact as a storytelling device for narrative-driven culinary curations

We encourage system designers to harness the materiality of the designed artifact, turning it into a storytelling device. This could potentially amplify the narrative potential, and open new possibilities for culinary creators, allowing them to further experiment and innovate in their choreographic endeavors.

This implication aligns with the concept of "material experience" that emphasizes the influence materials have on shaping ways of doing and practice, anchored deeply within the experiences they offer [22]. Particularly, our study confirms previous assertions on the connection between design aesthetics (spanning sensory, interpretative, and affective dimensions) and the performances enacted through its material essence [22]. Hence, designers aiming for narrative-driven culinary curations in computational food systems should judiciously factor in both design aesthetics and the interactive performances they can potentially inspire.

7 LIMITATIONS AND FUTURE WORK

This study has certain limitations. First, technical constraints influenced our choice of food materials. Since we were limited to aqueous droplets, it was challenging to incorporate many food ingredients that are highly viscous, such as sauces and condiments. This constraint limited the types of dishes we could design. Future research could explore other design possibilities, such as mixology or drinks, that might be more suitable for a liquid-driven system. Additionally, the system requires more effort to design and prepare a dish than traditional cooking methods. This additional effort could influence how chefs interact with the system, particularly in terms of their efficiency. On the other hand, this challenge might also provide an opportunity to foster more themed dining experiences.

Secondly, while our design outcomes, encompassing both conceptual and tangible designs that primarily focused on a more performative dining trajectory, we have not yet offered a feedback loop in the human-computational food interactions. There remains untapped potential in using these loops to create additional choreographies. Prior research suggested ways to technically implement this, for example, through capacitive sensing [16], that could pave the way for broader explorations in computational food design.

Our study focused on a specific dining context involving chefs and diners. We have not yet explored how computational food could be incorporated into different dining environments and situations. Future research could broaden the scope of dining contexts to include family-friendly engagement, and educational settings for food and technology schooling, involving collaborations with students, educators, and food designers. These contexts could support the development of further insights into the potential applications of computational food and its broader sociocultural impact.

8 CONCLUSION

In this research, we embarked on an exploration of computational food through the perspective of choreography, revealing the dynamics between creators, the computational food, and the consumers. Specifically, we presented six conceptual dish designs, two of which we brought to life, offering a blueprint for suitable culinary techniques and introducing new ingredients. Our findings unveiled six themes concerning computational food creation and consumption experiences, providing valuable insights for HFI researchers to delve deeper into computational food choreography. Furthermore, we identified four facets of culinary choreography and detailed associated design implications for future computational food designs. Our work aspires to leverage the choreographic potential of computational food design, paving the way for future HFI innovations.

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