GastroConcerto: Towards Designing Dining–Sound Pairings to Support Culinary Creativity

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Figure 1: A sonic dish crafted with *GastroConcerto* by a participating chef in Study 2.

Abstract

Sounds play a crucial role in shaping dining experiences. Recently, designers have increasingly integrated them into interfaces that connect diners with food. Yet, little is known about how sounds can function as culinary materials to enrich chefs' creativity, particularly in creating meaningful auditory interactions that resonate with their culinary creations. Hence, we present *GastroConcerto*, an auditory dining system that combines a magnetic contact microphone equipped under the plate with a companion mobile application. This system delves into the interactive space between diners and their food to introduce a novel interactive mechanism of *dining–sound pairing*, enabling chefs to design specific auditory interactions that respond to diners' individual interactions with the food on dining containers. Through a within-subjects study and field deployment, we examined how *GastroConcerto* enriches chefs' creative practices in crafting "sonic dish" experiences. Ultimately, our goal is to shift the ownership of auditory interaction design from interface designers to chefs, thereby supporting their culinary creativity.

CCS Concepts

• **Human-centered computing → Interaction design**.

Keywords

Human-food interaction, auditory interface, culinary creativity, acoustic sensing

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1 Introduction

Sounds are often designed to integrate with other sensory modalities during meals, enriching dining experiences [52], altering sensory perception [57], and influencing eating behaviors [59]. For example, prior research suggests that playing high-pitched sounds could stimulate sweetness and sourness, while low-pitched sounds correlate with bitterness [26]. Furthermore, eating sounds (e.g., chewing, licking) can affect diners' perceptions of food's crispness and freshness [58]. These studies have spurred interest within hospitality, such as music-themed restaurants adjusting soundscapes (e.g., volume, tempo) to influence eating pace [54], while blindfolded restaurants leverage sound to heighten sensory awareness [1]. These prior works have increasingly captured the attention of Human-Food Interaction (HFI) designers, striving to integrate auditory elements into food interactions [16, 18, 22, 47, 74].

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Auditory interaction in HFI has evolved from passive auditory enjoyment (e.g., background music) to active sound interaction, where sounds respond directly to diners' dining interactions. This evolution spans from edible auditory interfaces [14, 37] (e.g., sounds generated by food materials) to interactive auditory systems [73, 76, 78]. Building on this trajectory, recent HFI research has begun to investigate how chefs (here broadly defined as practitioners across the catering industry) employ interactive sounds as an emerging culinary resource to innovate their food creations [73]. However, these works are often constrained to lab-controlled experimentation, leaving little understanding of how auditory interaction can be integrated into chefs' daily culinary practices. Moreover, existing sound-related HFI systems have primarily relied on either triggering a single type of auditory output (e.g., sonification [37, 76]) or arranging sound playback randomly or sequentially [73, 78] to respond to dining interactions (e.g., licking [73, 76], sipping [77], interacting with plates [82]), regardless of how or what diners actually eat. Such an overlook of the interactive space between diners and food content limits chefs' expressivity in crafting meaningful auditory interactions. These interactions should reflect their most authentic culinary vision when creating sonic dishes [25, 40, 49, 73]. This culinary ability to skillfully curate each dish as a multisensory medium for creative expression [41] transforms individual dining moments into dynamically evolving experiential trajectories [25]. This motivates our overarching research question: *How do we design an auditory dining system that supports chefs' culinary creativity, while it could be further integrated into their daily culinary practices?* Building on these insights, we propose an interactive mode of dining-sound pairing that allows chefs to orchestrate diverse auditory responses to diners' unique interactions with their dishes.

We first conducted a formative study with seven chefs to identify key challenges in integrating auditory interactions into culinary practices for supporting creativity (Section 3). The challenges identified included time constraints, hygiene concerns related to device exposure, limited expertise in sound design, and the risk of distracting diners in public settings. Drawing on these findings, we derived four design considerations that guided the development of *GastroConcerto*'s appearance and functionality. To capture unique dining interactions, *GastroConcerto* incorporates a magnetic piezo sensor mounted beneath the plate, which detects acoustic signals generated by diners' specific interactions with their dishes (Section 4). We also provided a companion user interface that grants chefs autonomy to collect interaction data, categorize sound pairings, and assign specific sounds to each pairing that can be activated by diners during meals. This work addresses our overarching research question by proposing two sub-RQs:

- **Sub-RQ1:** *How does the dining–sound pairing mode in GastroConcerto support chefs' culinary creativity?* To address this, we conducted a within-subjects user study (Section 5) to evaluate the effectiveness of the dining–sound pairing mode in supporting chefs' culinary creativity, compared with a baseline system in which sounds were triggered sequentially. Sixteen chefs were recruited, and each participant was asked to create a novel appetizer using the assigned system along with the provided sound and food materials. The results indicate that the dining–sound pairing mode significantly enhanced participants' culinary creativity across dimensions of enjoyment, exploration, expression, and perceived worth of efforts. Moreover, it elevated chefs' sensory and emotional engagement with their dishes.

- **Sub-RQ2:** *How does GastroConcerto support chefs' culinary creativity in daily practice and facilitate gastronomic experiences?* To further investigate this, we iterated on the system based on findings from Study 1 and conducted a five-day field deployment with six chefs (Section 6), focusing on their daily culinary experiences of engaging with *GastroConcerto*. At the end of the deployment, six diners were invited to individual dining sessions to experience the chefs' final sonic dishes. Our observations highlight *GastroConcerto*'s potential to generate sonic dishes from food affordances, support chefs' daily creative practices, and facilitate both culinary awareness and mindful dining.

Overall, the contributions of this work are as follows:

- **System Design:** We introduce *GastroConcerto*, an auditory dining system that expands chefs' creative space by orchestrating diners' interactions with their dishes to activate corresponding sounds. The system offers inspiration for developers seeking to design novel digital dining interfaces that support culinary creativity and foster new dining experiences, extending beyond exsisting HFI approaches.
- **Empirical Understanding:** Our research engaged chefs throughout the process, from system development to evaluation, in order to examine how *GastroConcerto* contributes to culinary creativity through both a within-subjects experiment and a field deployment. These findings provide valuable insights for researchers and practitioners seeking to understand chefs' authentic perspectives on creating dining–sound pairings and incorporating such interactions into their daily culinary practices.
- **Design Implications:** Drawing on the study results, we propose the following actionable design implications: (1) leveraging food properties to enhance food expressiveness; (2) providing temporal support for digital food creations during chefs' culinary processes; and (3) employing digital properties to modulate diners' interoceptive experiences. These implications can guide the design of future digital dining interfaces that aim to support chefs' culinary creativity.

2 Related Work

This section reviews related work, focusing on prior culinary support systems and auditory interaction in HFI design, and extends this understanding toward the creation of an auditory dining system that can support culinary creativity.

2.1 Culinary Support Systems for Chefs

With the transformative developments of culinary education [21, 34], modern chefs are expected not only to craft flavorful dishes but also to present them in innovative and aesthetically compelling ways [41]. This trend has inspired HFI research to explore culinary support systems that enrich chefs' creative practices [17, 73]. For example, audio-visual dining performances such as "Le Petit Chef" and "Sound of the Sea" have been incorporated into culinary presentations to elevate the dining experience [27, 56]. However, these systems typically offer predefined narrative content, which constrains how chefs can flexibly engage with digital elements in ways that reflect their unique culinary vision. Some innovations, such as 3D food printing [75], shape-changing food [69], and electrowetting-based fluid control [17, 19] have begun to expand the creative repertoire available to chefs in the development of digital gastronomy. However, on the one hand, the food-crafting process and the orchestration of digital elements are often asynchronous, largely because of the lack of appropriate user interfaces. This results in researchers, rather than chefs, taking control of digital content authoring [14, 73]. On the other hand, such systems rely on specific types of food materials (e.g., pastes [75], droplets [17]) and tend to overlook the compositional diversity that is essential to the expressive potential of culinary creativity. These limitations make it difficult to fully integrate such systems into chefs' everyday practice. The digital elements in these systems are often unidirectional (designed primarily for display, e.g., projection [27, 56], food performance [17, 19]), missing the opportunity to incorporate the diverse ways in which diners interact with their food into responsive dining experiences.

These explorations suggest that systems supporting culinary creativity should not only facilitate chefs' multisensory food practices but also empower them with autonomy to orchestrate digital elements within their culinary workflow, thereby aligning with their authentic creative vision. Moreover, the design of such systems could benefit from incorporating the interactive space between diners and their dishes, thereby creating meaningful digital dining experiences.

2.2 Auditory Interaction in HFI

In dining environments, both the intrinsic sounds of food (e.g., glutinous textures, crunchiness) and external auditory stimuli (e.g., dining soundscape) have been used to shape the perception of flavors and textures [38], and to influence eating behaviors [66]. This growing understanding has led HFI researchers to explore the potential of auditory stimuli in transforming dining experiences [52].

First, edible auditory interfaces focus on food properties like dryness [14, 37] and moisture [76]. For example, "FoodSkin" used edible gold foil circuits on cookies to trigger sounds by detecting resistance and capacitance changes [37]. While promising, such designs require external circuits and are limited to specific food materials, challenging the integration into chefs' culinary practices. Therefore, dietary tableware interfaces have attracted increasing attention. These include utensils that sense eating patterns (e.g., IMU-enabled cutlery [36]) or detect eating phases (e.g., straws equipped with capacitive sensing [72, 77] or pressure sensing [29]). However, these often fail to showcase chefs' creations and may trigger sounds without direct food contact, potentially hindering the inherent connection between auditory experience and eating. This limitation also extends to head-mounted sensors designed to capture eating actions [39, 78, 83]. In addition, some works take the form of dining containers. For instance, "Funeat" employs weight-sensing plates to drive audiovisual performances [82], and systems

Table 1: We summarize three sensing approaches from prior sound-related HFI works, with the brackets showing the auditory interaction mode of each work. Uploading refers to inputting sound materials (e.g., downloading, recording) to be used during the eating experience. Sonification refers to the process of translating real-time eating-related data streams into sound.

Dining Action Sensing Approach	Research Name (Auditory Interaction Mode)
Capacitive Sensing	SonicStraw [77] (Uploading), WeScream! [76] (Sonification), EducaTableware [36] (Uploading), FoodSkin [37] (Sonification)
Motion Sensing	SUI [29] (Sonification), Chewing Jackey [39] (Uploading), FunEat [82] (Uploading), Gustosonic-Sense [78] (Uploading)
Acoustic Sensing	Gamelunch [50] (Sonification)

such as "Gamelunch" map eating-related acoustic signals to interactive sounds [50]. Although these platforms enable dish display, they remain largely diner-centered and overlook the unique dining interactions that could meaningfully inform or respond to crafted auditory content for chefs. Therefore, we categorize existing dining sensing approaches into three groups from prior sound-related HFI works (see Table 1), in order to inform the subsequent development of culinary support systems that incorporate auditory interaction.

Some systems allow sound uploading to trigger engaging sounds either individually [36, 82], randomly [77], or sequentially [73]. However, this often creates a misalignment between sound presentation and food content as diners consume their meals, making it difficult for chefs to use sound as a controllable culinary resource to represent their creative intentions. Sonification techniques, by contrast, can react to how diners consume their food based on variations in dining signals. Yet their reliance on customized algorithms without consistent evaluation often results in unpredictable user experiences and limited reusability [20, 33]. Moreover, sonification is typically restricted to symbolic music patterns (e.g., MIDI notes), which provide limited expressive information for chefs' creativity [7]. To address these limitations, we developed an interactive mode of dining–sound pairing, based on the sound-uploading pattern, that enables chefs to orchestrate auditory contents that respond to diners' unique interactions with their sonic dishes.

2.3 Summary

Culinary creativity, as an expression of a chef's inner world [41], is manifested through the processes of conceptualization, preparation, cooking, and presentation, and ultimately realized through diners' perceptions and interpretations [49]. Based on this understanding, our review identified two key insights: (1) The advancement of interactive technologies is reshaping the relationship between chefs and diners, allowing this relationship to extend beyond the confines of the kitchen [17] toward a more open and participatory role in designing the dining experience [4]. By creating meaningful auditory cues that respond to diners' unique interactions with their dishes, chefs can deepen engagement and enhance diners' understanding of their culinary creations. (2) In response to chefs' evolving intentions during the culinary process, auditory interactions should be integrated into their everyday culinary routines to provide instant responses to their experiments with ingredient composition and sensory exploration.

3 Formative Study

To investigate the potential identified in prior work for supporting chefs' culinary creativity through auditory interaction, we propose a dining–sound pairing mode that enables chefs to orchestrate diverse auditory responses to diners' unique interactions with their culinary creations. Building on this mechanism, we conducted a formative study with seven chefs (age; M = 28.29 years, SD = 3.20; 5 men, 2 women; from P1 to P7) who possessed extensive culinary experience (M = 6 years, SD = 3.61), prior experience with interactive technologies in their culinary practices, and interest in enhancing culinary creativity through auditory interaction (see Appendix Table 4 for details). Grounded in reflective practice, this study aimed to generate design considerations of appearance and functionality for developing an auditory dining system that can be integrated into chefs' daily culinary practices. It serves as a key step toward deploying dining–sound pairing and examining its impact on culinary creativity.

3.1 Procedure and Challenges

This study was conducted by 30-minute semi-structured interviews with each participant [43], consisting of three phases: (1) Knowledge alignment (5 min): The researcher presented slides and videos to help participants develop a conceptual understanding of HFI research, particularly auditory interactions in dining scenarios. (2) Open-ended discussion (20 min): Participants reflected on their culinary experiences, the challenges of using interactive technologies, and their perspectives on integrating auditory interactions. (3) Design elicitation (5 min): Participants were encouraged to envision future deployments of auditory dining systems based on their culinary experience. All sessions were audio-recorded for transcription. Two researchers independently reviewed and coded the transcripts, and the results were synthesized through collaborative discussion, leading to the identification of five key challenges:

- **C1: Auditory interactions may increase time costs.** Chefs found auditory interactions potentially time-consuming due to distractions (P3), training (P3, P5), managing customer flow (P4), added complexity (P1, P4, P6), and adapting to menu changes (P2, P6). Simplicity and quick interaction were crucial. P2 described her experience with audio-visual interactive projections in her restaurant during seasonal changes: *"Every time I change the menu, I need to replace and edit all the animations to match my dishes [...] This is so expensive."*

- **C2: Exposed electronics may distract from the food.** Exposed electronic components could detract from the dining experience. Chefs wanted the focus to remain on the food, with technology feeling natural and unobtrusive. P7 explained, *"Technology shouldn't become a gimmick [...] it should highlight the food itself. [...] I [hope my customers] experience this interaction naturally, without it feeling too deliberate."*
- **C3: Hygiene and cleanliness concerns.** Interactive technology raised hygiene concerns, including bacterial exposure and cleaning burdens. Separating sensing components from tableware was suggested for better hygiene and reusability. P3 emphasized, *"[We need to] work while wearing masks and hats. If we use these devices, [...] they might expose us to bacteria and add an extra cleaning burden."*
- **C4: Limited sound expertise may hinder creativity.** Chefs perceived sound as a low-cost yet customizable interactive feature. However, due to their limited expertise in sound design, some expressed the potential benefits of automated sound orchestration (P3, P4) and access to an extensive sound library (P2, P6, P7). As P4 expected, *"If there were an AI system, I could simply tell it through the voice commands to add any elements to my dish [...] it would significantly reduce my workload."*
- **C5: Potential for messy sound experiences in public spaces.** Chaotic sounds in multi-dining settings could disturb guests. Limiting sounds to small ranges was recommended to minimise disruption. P6 commented: *"Some guests just want to quietly read a book at the café [...] loud public sounds might disturb them."*

3.2 Design Considerations

To synthesize the insights gained from these challenges (labeled C) and from researchers' self-reflections during early-stage experimentation (labeled R), we identified four key design considerations, spanning both system appearances and functionality, that inform the development of *GastroConcerto*.

3.2.1 ***DC1:*** *Design a sensitive, isolatable, and non-contact sensing hub.*

The core of *GastroConcerto*'s interaction design lies in dining–sound pairings, which require sensors capable of capturing dining interactions in real time and supporting reliable classification. We identify three key requirements: (1) *High Sensitivity (R)*: sensors must accurately capture data streams at a high sampling rate to enable precise recognition and classification of dining interactions. (2) *Environmental Isolability (R)*: sensors should resist noise from conversations and other dining activities to ensure localized and reliable interaction detection. (3) *Non-Contact Sensing (C3)*: sensors should maintain hygienic separation between the sensing hub and containers while detecting dining interactions without requiring direct contact with the human body and food.

3.2.2 ***DC2:*** *Design for instant responses with memory functionality.*

Auditory interactions introduce inherent time costs for chefs, as new interaction modes often bring unfamiliar qualities that disrupt the initial balance of creating, cooking, and serving [30, 68, 71]. To mitigate this, the interface should provide: (1) Instant Responses (C1): enabling chefs to create dining–sound pairings that provide immediate auditory feedback and allow dynamic adjustments aligned with their creative thinking in culinary practices. (2) Memory Functionality (C2): storing configurations of each sonic dish to support the retrieval of established records, facilitate iterative refinement, and enable rapid redeployment during service.

3.2.3 ***DC3:*** *Design an expressivity-supportive, modular, and food-grade dining container.*

Food containers, along with the diverse food mediums they hold, offer affordances that support a range of dining interactions from food preparation to consumption [42]. At the same time, containers have long served as a medium for chefs to express culinary creativity and have become a key focus in HFI research [36, 50, 76, 82], as the eating behaviors they scaffold present opportunities for integrating auditory interactions to enhance the dining experience. Therefore, the structural configuration emphasizes: (1) *Expressivity-supportive (C2)*: containers should support creative presentations for chefs while remaining practical for diners. (2) *Modularity (C3)*: components must be easily assembled and cleaned for sustainable reuse. (3) *Food-grade Materials (C2)*: adopting high-temperature-resistant, non-toxic, and hygienic materials for constructing the enclosure and dining components.

3.2.4 ***DC4:*** *Design a convenient, personalized, and enjoyable auditory interaction.*

Unlike prior sound-related HFI systems, where designers controlled auditory authoring [14, 73, 76], *GastroConcerto* shifts the ownership of auditory interaction design from interface designers to chefs. It empowers chefs to assign sounds from an extensive sound library *(C1)* and to upload their own audio files *(C4)*. The system also supports both speaker-based and headphone-based playback, enabling diners to choose between shared and private sonic dining experiences *(C5)*.

4 *GastroConcerto*: Design and Development

We present *GastroConcerto*, an auditory dining system consisting of three key components (Fig.2): (1) a sensing hub that captures diners' dynamic interactions using a customized algorithm; (2) a dining platform with plateware that accommodates food items and interfaces with sensors beneath to compute dining interactions occurring on it; and (3) an initial web-based user interface that enables chefs to create sonic dishes by categorizing dining–sound pairings within each dish and assigning specific sounds to each pairing.

4.1 Developing the Sensing Hub

Through the review of auditory interaction techniques in HFI (Table 1), we experimented with five types of sensors to investigate whether different data streams could effectively detect and classify dining interactions on the plateware. By evaluating these sensing approaches, our aim was not only to determine which sensor best suits *GastroConcerto*, but also to understand why certain sensing mechanisms are more appropriate for real-world dining scenarios. We incorporated these sensors into a set of initial prototypes (Fig.3). Six participants (age: M = 22.83 years, SD = 1.6; 4 men, 2 women) were invited to engage with these low-fidelity prototypes (Participants' details in Appendix Table 5). We observed participants' interactions and responses while using each prototype, evaluating

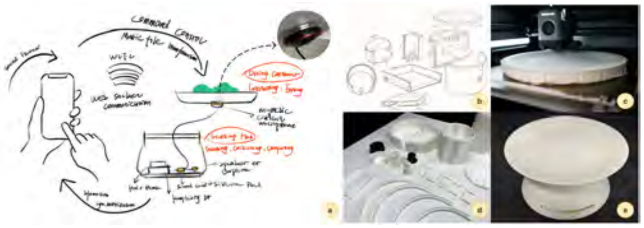

Figure 2: The development process of *GastroConcerto*. (a) Sketching the interaction workflow within *GastroConcerto*. (b) Designing structural component details in the early iteration. (c) 3D printing. (d) Early prototype of a 3D-printed component. (e) Showcasing the final version of *GastroConcerto*.

them according to the three sensing criteria outlined in Design Consideration 1.

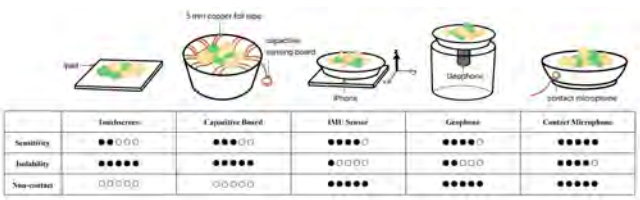

Figure 3: Exploring the Potential of Five Sensors: Touch Screen, Capacitive Board, IMU, Geophone, and Contact Microphone. Researchers evaluated these sensors based on users' performance during interaction. Note that the in-the-field photos are included in the Appendix Fig.14.

4.1.1 *Capacitive Sensing.*

We tested two capacitive sensing approaches: (i) an iPad touchscreen and (ii) plateware equipped with an Adafruit board and 5 mm copper foil tape. These sensors detected dining interactions with high precision but required direct contact with both containers and food, complicating subsequent cleaning. These sensing approaches imposed strict constraints on food moisture: dry foods were often undetectable, whereas overly moist foods frequently caused signal misfires or delays. Meanwhile, capacitive sensing can capture only instantaneous changes in capacitance at the moment of interaction, making it unable to represent the dynamic and continuous temporal structure of dining interactions for classification.

4.1.2 *Motion Sensing.*

We explored continuous motion data streams from (i) an iPhone IMU (z-axis acceleration) and (ii) a Geophone vibration sensor to detect dining interactions on the plateware. While both were sensitive to motion changes and promising for non-contact applications, they suffered from poor signal isolation. (1) The IMU had to remain parallel to the plateware, any rotation during dining caused auditory confusion. (2) Geophone signals were easily corrupted by footsteps and table impacts. We 3D-printed a platform to hold the Geophone inverted, but this introduced abnormal fluctuations, likely due to gravity displacing its internal suspension springs. (3) Both sensors also struggled to capture subtle dining interactions, often requiring exaggerated motions to trigger sounds.

4.1.3 *Acoustic Sensing.*

We mounted a piezo contact microphone on the outer wall of the plateware to capture the acoustic signatures of dining interactions. This sensor provided high sensitivity, physical separation from food, and strong resistance to interference from human voices. However, table vibrations occasionally disrupted the signals, which we mitigated by placing rubber studs beneath the container.

Overall, we adopted contact microphones, paired with a Raspberry Pi for rapid prototyping and interaction. Additionally, we integrated a magnetic module into the contact microphone for easy attachment to dining containers.

4.2 Designing the Functionality

To establish the mechanism of dining–sound pairings, we initially developed a web interface for accessing *GastroConcerto*. This interface empowers chefs with autonomy to create sonic dishes in real-time data collection, model training, and sound assignment. Its key functionalities include:

4.2.1 *Creating a dish.*

On the homepage, chefs first enter the local network IP to connect with the Raspberry Pi. They then select "Create Dish" to name their dish, e.g., "Smoked Salmon."

4.2.2 *Establishing dining-sound pairings within the dish.*

Chefs define potential pairings within their dishes, such as sounds triggered when cutting salmon or dipping it into sauce, if the sensor captures the corresponding acoustic signals. This involves:

(1) *Acoustic data collection*: Chefs click "Record" to store `.wav` files for model training. We used a fixed-size deque buffer to retain the five most recent frames, ensuring both contextual continuity and event completeness. To segment dining interactions, we implemented a peak-based sliding window method [81]: when the amplitude exceeds the threshold, an event is marked and the buffered data are added. A finer 0.5× window is then applied to refine the start and end points until amplitudes remain below the release threshold for 0.5 s. Each pairing is recorded 15 times.

(2) *Acoustic data analysis*: We employed a Random Forest model, as prior research has shown it to be among the best-performing machine learning methods for classifying eating actions [78]. Audio data were processed into time- and frequency-domain features, with each segment represented as a fixed-length vector. The trained model and its corresponding normalizer were then stored within the dish file.

4.2.3 *Assigning sound to each pairing.*

After training, chefs assign sounds to each pairing. The dish status is displayed as "Completed" once training is finished, or "Pending" otherwise. To support this process, the system provides a sound library with a wide range of predefined options and also allows chefs to upload their own custom sounds.

4.3 Designing the Dining Platform and Plateware

We 3D-printed the plateware using food-safe PETG. A recessed area was designed at the base to house an iron ring for attaching magnetic contact microphones, while ensuring that the containers remain easy to clean and sterilize. A separate platform accommodates the electronic components, maintaining aesthetics and minimizing interference with the dining experience. To further reduce non-dining signal interference, a silicone rubber layer was embedded beneath the platform. In addition, we designed a detachable partition with a circular opening to enable precise alignment and secure attachment of the microphones between the platform and plateware. The raised pedestal form echoes East Asian offering vessels (e.g., Japanese takatsuki and Chinese high-footed plates), which traditionally elevate food to confer respect and ceremonial significance. This elevated presentation is also reflected in recent HCI works [11, 12], highlighting food for multisensory interaction.

5 Study 1: Evaluating the Effectiveness of Dining–Sound Pairing in Supporting Culinary Creativity

To evaluate the effectiveness of the dining–sound pairing interaction mode in the *GastroConcerto* system, we conducted a within-subjects study with 16 chefs. The goal was to examine how this interaction mode supports culinary creativity in comparison to a baseline condition, where sound playback was triggered sequentially (Fig.4).

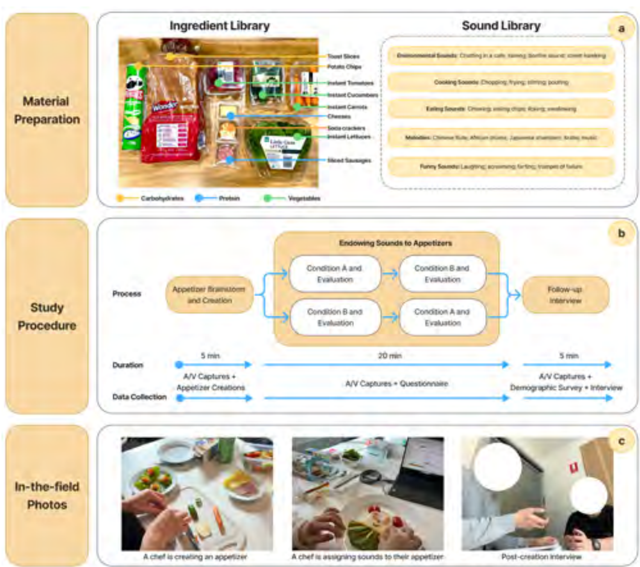

Figure 4: Flowchart of Study Procedure. (a) preparation of materials (ingredient and sound libraries), (b) study procedure for endowing sounds to appetizers across two conditions, and (c) in-the-field photo.

5.1 Participants

16 chefs (age: M = 29.5 years, SD = 7.56; 6 men, 10 women), distinct from those in the formative study, were recruited through social media and word-of-mouth. All chefs had several years of experience in food innovation with backgrounds in the catering industry (M = 5.13 years, SD = 5.77), including but not limited to western chefs, baristas, restaurateurs, and bartenders. The sample size of 16 was determined based on an a priori power analysis using G*Power (two-tailed, $\alpha = 0.05$, power = 0.80, Cohen's d = 0.8).

5.2 Procedure

We provided participants with a curated set of ready-to-use ingredients and a sound library to design an appetizer (Fig.4 (a)). Appetizers were selected for their simplicity and non-cooking nature, which not only streamlined the study procedure but also enabled participants to effortlessly and rapidly conceptualize and express their culinary creativity. The constrained creative sound library aimed to control experimental variables while maintaining sufficient room for creative expression. The *GastroConcerto* system was deployed in a controlled lab environment, consisting of an interactive platform and two distinct web interfaces (Fig.5), each corresponding to one of the following interaction modes:

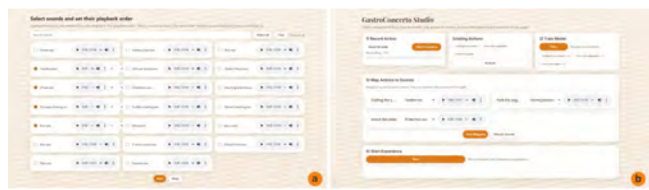

Figure 5: Demonstration of the web interface for the two conditions. (a) In Condition A, chefs can select sounds and arrange their playback order. (b) In Condition B, chefs can create dining–sound pairings and assign sounds to each pairing.

- **Condition A (Baseline)**: This condition retained the default system configuration and visual interface of *GastroConcerto*, with only the web interface modified to allow participants to select sounds and arrange their playback sequence. This mode reflects the conventional auditory interaction approach commonly used in HFI research to enrich culinary creativity [73].
- **Condition B (Dining–Sound Pairings)**: In this condition, participants used the same appetizer to fully engage with the *GastroConcerto* system to identify different dining actions associated with consuming the dish. The system then performed real-time data collection, categorized the dining–sound pairings, and assigned a specific sound to each pairing.

Participants were required to attend a session lasting 30 minutes. During the study, they were guided to complete and evaluate their appetizer creations under different conditions. Culinary creativity is defined as the transformation of a chef's inner world into a perceptual culinary experience [25, 41], closely reflects personal expression and internal intentions. Therefore, we adopted self-assessment of chefs rather than third-party expert evaluation, aligning with prior HCI research on creativity support [28, 48]. Data were collected through questionnaires, as well as audio and video recordings that captured participants' conversations, interviews, and dining behaviors. To enhance interpretability, we also illustrated outcomes of chefs' creations under both conditions in Appendix Table 6.

5.2.1 *Stage 1: Appetizer Brainstorm and Creation (5 minutes).*
At the beginning of the session, each participant was asked to create an adequate serving of an appetizer using the provided ingredients, then divide it into four portions for use in the subsequent interaction conditions. After completing the appetizer, participants tasted the first portion. This task was designed not only to simulate a realistic culinary creation process [49] (from preparing, processing, to tasting) but also to prompt reflection on their culinary creativity as food innovators.

5.2.2 *Stage 2: Assigning Sounds to Their Appetizers (20 minutes).*
To avoid ordering effects, both the conditions and the sequence of tasks were counterbalanced across participants. Participants in the baseline condition used one portion of the appetizer to assign sounds and determine their playback sequence. Participants in the pairing condition used two portions: the first for collecting dining interaction data, after which the researcher cleaned the plate, and the second for the actual interaction and tasting.

After each condition, participants completed assessments of their perceived culinary creativity before proceeding to the next. Culinary creativity was especially reflected not only in the process of creation but also in the act of perceiving and consuming the dish [49]. Therefore, in addition to a culinary creativity investigation, participants were asked to taste their creations and complete a questionnaire to evaluate their dish. Each participant was required to plate their appetizer on our system and engage in at least five interaction attempts with it to fully experience the differences between conditions. A 2-minute break was provided between each stage to minimize carry-over bias caused by self-evaluation of the dish [31, 40, 67].

5.2.3 *Stage 3: Follow-up Interview (5 minutes).*
After completing all conditions, the researcher conducted a brief follow-up interview to collect participants' immediate feedback regarding the culinary creativity support and their overall experience. The interview focused on the following open-ended questions, among others: "*Compared to traditional culinary innovation, how did the presence of sound affect your creative experience?*", "*How would you describe the difference between these two auditory interaction modes?*", "*Do you have any additional comments?*"

5.3 Measures

After each condition, participants completed a questionnaire assessing both their perceived culinary creativity and their evaluation of the dish they created. Responses were collected using a 10-point Likert scale (1 = not at all, 10 = extremely). To evaluate culinary creativity, we adopted the validated Creativity Support Index (CSI) questionnaire [13], which captures dimensions such as enjoyment, immersion, exploration, expressiveness, and results worth the effort. Since our study did not focus on collaboration with other chefs, we marked the collaboration-related questions as N/A in the final calculation of the CSI score. For dish evaluation, we adapted a validated dining questionnaire [80], which reflects three key indicators emphasized in the prior HFI works: dining awareness [5, 6, 10, 79], sensory appeal [10], and emotional engagement [6, 79]. The questions were as follows: "*I noticed subtle flavor variations in the dish,*" "*The dish increased my appetite,*" and "*I felt an emotional connection to the dish.*" In addition to these self-report measures, we also collected behavioral indicators during the study (Table 2). We assessed the normality of the data using the Shapiro-Wilk test. Depending on the distribution, we then applied the Wilcoxon signed-rank tests for these non-parametric data.

5.4 Results

5.4.1 *Analysis of Subjective Culinary Creative Support.*
Wilcoxon signed-rank tests showed that (Fig.6), compared to the baseline system, the dining–sound pairing mode significantly enhanced participants' culinary creativity as reflected in overall CSI scores ($Z = 3.051$, $p = .002$). In particular, significant improvements were observed in several dimensions: enjoyment ($Z = 2.586$, $p = .010$), exploration ($Z = 2.431$, $p = .015$), expression ($Z = 2.223$, $p = .026$), and perceived worth of effort ($Z = 2.575$, $p = .010$). These results suggest that the dining–sound pairing mode not only improved chefs' creativity in crafting sonic dishes but also stimulated participants' emotional engagement and exploratory motivation during dish creation. In the evaluation of the sonic dishes, the dining–sound pairing mode also received significantly higher ratings in sensory appeal ($Z = 3.068$, $p = .002$) and emotional engagement ($Z = 2.953$, $p = .003$), indicating that the pairing mode amplifies chefs' sensory perception and affective responses to their own creations.

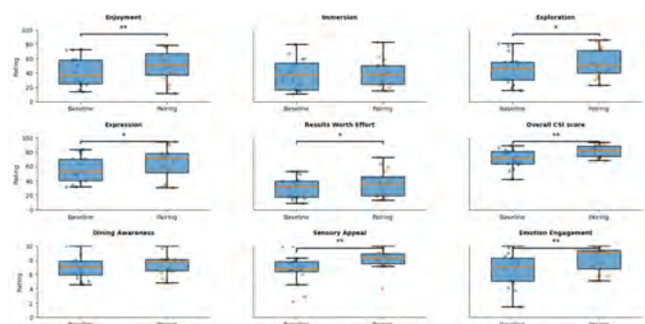

Figure 6: Culinary Creativity (first two rows) and Dish Evaluation (third row) Ratings under Two Conditions (Baseline = Condition A; Pairing = Condition B). CSI rating includes weighted factor scores for each dimension as well as the overall CSI score. Asterisks indicate significance levels: *p < .050, **p < .010, ***p < .001.

5.4.2 *Analysis of Interaction Behavior Indicators.*
Wilcoxon signed-rank tests indicated that (Fig.7), under the dining–sound pairing mode, chefs demonstrated significantly greater engagement across multiple behavioral metrics: Creation Duration ($Z = 3.517$, $p < .001$), Interaction Duration ($Z = 3.26$, $p = .001$), Number of Interactions ($Z = 2.956$, $p = .003$). In terms of sound usage, chefs employed a significantly lower Number of Sounds ($Z = -3.108$, $p = .002$) in the pairing mode compared to the baseline. These results indicate that the dining–sound pairing mode fostered deeper interactive involvement and sustained engagement, as reflected in longer creation

Table 2: Behavioral Metrics

Behavioral Metrics	Description
Creation Duration	The total time spent on dish creation, measured from the moment the participant began using the web interface until completion.
Interaction Duration	The total time spent interacting with the dish via the system.
Number of Interactions	The total number of interactions with the dish, including all detected dining actions.
Number of Sounds	The total number of sounds chefs select for their dishes.
Number of Sound Responses (NSR = NCR+NER)	The total number of times a sound was played in response to an interaction during the entire session.
Number of Pairing Interactions (NPI = NCR+NER+NNR)	The total number of times a sound was played in response to an interaction during the entire session.
Number of Correct Responses (NCR)	The number of pairing-related interactions that triggered the correct corresponding sound.
Number of Error Responses (NER)	The number of pairing-related interactions that triggered an incorrect sound.
Number of No Responses (NNR)	The number of pairing-related interactions that did not trigger any sound.

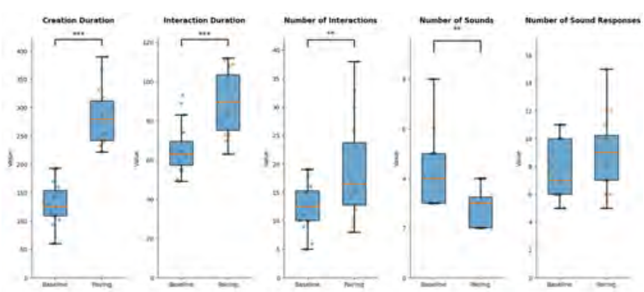

Figure 7: Behavioral Interaction Analysis Ratings under Two Conditions (Baseline = Condition A; Pairing = Condition B). Asterisks indicate significance levels: *p < .050, **p < .010, ***p < .001.

time and more frequent interactions. Meanwhile, chefs employed fewer sounds, suggesting a more selective and cautious approach to sound usage. However, no significant difference was found in the Number of Sound Responses ($Z = 1.688$, $p = .091$), prompting further analysis of the interaction dynamics in the pairing mode.

5.4.3 Analysis of the visual articulation of typical dining–sound pairing combinations. In this study, the dining–sound pairings were grounded in each participant's own interactions. Because the acoustic signal is shaped by the users' dining interactions, the food materials, and the specific diningware, even the same interaction can produce different signal patterns across participants. Consequently, computing a machine learning accuracy benchmark would not provide a reliable baseline for *GastroConcerto*. Instead of predictive modelling, we adopted a bricolage analysis strategy [53], adapting visual articulation methods from HCI [65] to construct a descriptive model of the system's sensing capability. One researcher analyzed the video recordings of all chefs' creation processes together with the corresponding dataset (Appendix Table 6) to identify: (i) the combinations of dining-sound pairings that produced robust and distinguishable event patterns; (ii) known failure modes; and (iii) the material or interaction properties underlying these limitations. We used interaction sound duration and pitch as two example axes to construct the visual articulation (Fig.8). We then selected four representative chef creations as illustrative cases.

Figure 8: Showcasing Sound Response Effects (a) and Accuracy for Pairing-Related Interactions (b) and four typical dining-sound pairing combinations from chefs (c-f)

During the dining–sound pairing mode, only 52.38% of all interactions were actually pairing-related. Moreover, as shown in Fig.8(a), the system did not respond to every pairing-related interaction (non-response rate: 12.73%). Through further reviewing chefs' creation, data revealed that chefs designed between two and four dining–sound pairings. The most common dining interactions were stabbing (26.09%), cutting (15.22%), lifting (15.22%), and stirring (13.04%). Yet even when chefs performed the same interaction, the acoustic patterns captured by *GastroConcerto* varied considerably depending on the food material (e.g., crackers vs. cucumber), the utensils used, and the speed or force of the interactions. For example, to ensure that the intended sound could be reliably triggered within this sensing mode, P15 created two stabbing pairings using different food materials. This sensing mode also suggests that, in principle, chefs could design more dining–sound pairings if the interactions exhibit clearly distinguishable acoustic characteristics. However, it is important to note that some dining interactions, although performed differently, can still generate overlapping acoustic signatures (e.g., the red and yellow segments in Fig.8(e)), which potentially leads to the error responses. Despite this, the pairing mode achieved a 93.10% accuracy (Fig.8(b)) in matching appropriate auditory responses to the recognized dining actions. This indicates strong effectiveness in distinguishing between dining types and triggering corresponding sounds. These findings and limitations were synthesised by the researchers and documented as prior knowledge to inform chefs in the next stage of the study.

5.4.4 Qualitative Analysis. We combined each participant's response to each question as a unit of qualitative data. In total, there were 55 data units, with the number of responses per participant ranging from 2 to 7 (M = 3.44, SD = 1.54). A reflexive thematic analysis [8] was conducted by one researcher on these data units to explore how auditory interactions influenced the creative experience compared to traditional culinary creation, and how the two sound interaction modes differed in their culinary experiential process.

Blending Sound into Culinary Expression. 7 participants described creating sonic dishes as a novel form of inspiration distinct from everyday cooking. For instance, P3 noted that sonic creation opened up new creative possibilities. P15 shared:"*As an owner, adding sound to a dish could differentiate me from other restaurants.*" However, compared to ambient music, P16 emphasized the personalized nature of auditory interaction:"*Designing this interaction helps me communicate something specific to a particular diner. [...] The music played in a cafe is meant for everyone, but this is for someone.*"

Sound as a Means of Amplifying Sensory Perception. 15 participants highlighted the novelty and intensity of the sensory experience brought by sound. P12 explained:"*The sound even made me feel a slight change in taste, it made me focus more on the flavor. [...] When I ate the first dish (referring to the no-sound task), I just swallowed it without thinking.*" Similarly, P2 reflected:"*This sound experience suddenly made me feel like this appetizer wasn't too salty anymore.*" P6 echoed this effect by describing how sound encouraged eating:"*The point of sound is that, even if the food isn't that great, it makes me want to keep going, just to see what happens next.*" Interestingly, P7 described a playful moment when he let the chips fall onto the plate to make a screaming sound: "*This is so funny, it feels like my chips are yelling at me.*"

Comparison between Sequential and Pairing Modes. While both interaction modes were described as "*innovative*" and "*playful*," participants distinguished their culinary expressive characteristics. The sequential mode was characterized as "*creating a story context*" (P13, P16) and "*exploratory*" (P6), whereas the pairing mode was described as "*more connected to the food*" (P4, P12), "*logical*" (P5, P11), and capable of "*expressing the meaning behind the dish*" (P4, P7). P11 reflected:"*The sequential mode helped spark creativity in people who might not usually see themselves as creative. [...] As for the pairing mode, it felt like there was a real connection between the diner and the dish I created [...] it created more meaningful interactions.*" P16 further emphasized the difference in agency:"*[The sequential mode] felt more like I was exploring the sounds. [...] But for another one [referring to pairing mode], it was more about exploring the food itself. I really had to think about how to design the interactions that could trigger specific sounds.*" Participants also shared their attitudes toward the mechanisms behind the two interaction modes. P4 commented on the sequential mode, "*Sounds played every time I interacted with my dish [...] It could get overwhelming and even a bit annoying after too many trials.*" In contrast, P18 reflected on the pairing mode: "*The sound didn't appear everytime [...] I could just focus on my dish. When the sound did happen, it was a surprise.*"

6 Study 2: In the Field

To investigate how auditory interaction in the *GastroConcerto* system facilitates creativity in daily culinary practice and influences the gastronomic experience, we conducted a five-day field study with six chefs. On the sixth day, each chef hosted a dining session with an invited diner to experience the sonic dish they had created.

6.1 System Iteration

We retained the overall structure of *GastroConcerto* and iterated on the system to better support its use in Study 2. First, the web interface used in Study 1 was redeveloped into a mobile app using Android Studio (Fig.9). We also established automatic communication between the Raspberry Pi and the app at boot by registering a startup script, aiming to integrate the system into chefs' everyday culinary practices in a more portable and user-friendly manner. In addition to the plateware, we designed custom bowlware and drinkware to support the diverse culinary practices of chefs across professions. We also enriched the sound library by expanding the audio repertoire to support expressive sonic culinary creations. Furthermore, we adjusted algorithmic parameters, such as incorporating normalized entropy to improve action recognition accuracy and reducing the interaction release time from 0.5s to 0.1s to minimize sound response latency. To prevent prolonged audio from masking subsequent interactions, we added a mechanism to detect new actions: if a new action is performed more than three times consecutively while the previous sound is still playing, the system immediately switches to the corresponding sound, thereby preserving the authenticity of the chefs' creative intent. To improve the generalization ability of each trained model, we employed audio data augmentation techniques, including time stretching, volume scaling, pitch shifting, and the addition of subtle noise, to expand the number of samples for each dining interaction label and reduce overfitting.

6.2 Participants

We recruited six chefs through online advertisements and follow-up invitations sent to participants from Study 1 who had expressed interest in further participation. All participants had several years of experience in the catering industry (Years of experience: 4–20; M = 9.17, SD = 5.87), and ranged in age from 27 to 45 (M = 32.83 years, SD = 7.21; 4 men and 2 women; 2 from Study 1; indexed C1 to C6). Participants were required to be enthusiastic about culinary experimentation and creative food innovation, as well as open to integrating auditory interaction into their everyday culinary routines. Six diners (age: M = 29.17 years, SD = 3.76; 2 men and 4 women;

Table 3: Participant demographics. Note that participants only identified with binary genders (woman (W), man (M)). We also added each chef's work environment, classified according to Canziani's restaurant framework [9], which includes fine dining, casual dining, and quick-service restaurants.

Group	Code (Age, Gender)	Occupation	Attitudinal label for chefs / Sound enjoyment approach for diners	Experience of food-related practice
1	C1 (36, W)	Chef (Private chef)	Positive	10 years of experience crafting desserts and working as a private chef.
	D1 (37, M)	Psychologist	Speaker	Enthusiastic about exploring new culinary experiences, with a unique perspective on the intersection of food and psychology.
2	C2 (28, W)	Bartender (Casual dining restaurant)	Mild	5 years of experience running a bar, specializing in beverage experiences.
	D2 (28, W)	Master student	Speaker	Passionate about food experiences and previously participated in food–sound interaction research.
3	C3 (33, M)	Chef (Casual dining restaurant)	Positive	10 years of experience working in Chinese restaurants.
	D3 (25, M)	Master student	Earphone, Speaker	Passionate about food experiences and previously participated in food–sound interaction research.
4	C4 (28, M)	Japanese cuisine chef (Fine-dining restaurant)	Positive	6 years of experience creating dishes in Japanese buffet restaurants, including 2 years of private kitchen service.
	D4 (27, W)	Food blogger	Earphone, Speaker	Dedicated to exploring new culinary experiences and sharing them through public media platforms.
5	C5 (45, M)	Chef (Casual dining restaurant)	Positive	20 years in the catering industry and running a central kitchen company
	D5 (29, W)	PhD student	Earphone, Speaker	A PhD student who has previously participated in two food-related research studies.
6	C6 (27, M)	Greek cuisine chef (Casual dining restaurant)	Positive	Graduate of Le Cordon Bleu with 4 years of experience in Greek restaurants.
	D6 (29, W)	PhD student	Earphone, Speaker	Considers herself a food enthusiast who enjoys exploring new restaurants and discovering new cuisines.

indexed D1 to D6) were each paired with chefs to experience their final sonic dish, forming six pairs in total (Table 3).

6.3 Methods

We engaged the chefs in two sessions: a daily engagement experience for five days and a subsequent dining session, during which they crafted a sonic dish for diners. Through these two sessions, we aimed to explore how auditory interaction could support their everyday culinary practice and investigate its impact on shaping their overall gastronomic experience.

6.3.1 Daily Engagement Experience for five Days. This ongoing engagement encouraged participants to actively interact with the system and explore its creative potential, allowing them to experience how auditory interaction could be integrated into their everyday culinary practices. The ultimate goal of the session was for each participant to design a sonic dish and present it to an invited diner. The procedure was structured as follows (Fig.10):

Day 1 – Introduction and Deployment (40 min): A researcher visited each participant's home to deploy the *GastroConcerto* system and ensure that both the mobile device and the system were connected to the same Wi-Fi network. The researcher demonstrated how to operate the system and guided the participant through a practice process using a simple food. Once system functionality was confirmed and the participant was familiar with the basic operations, the researcher left and provided a printed manual with illustrations and instructions for their reference.

Days 1 to 5 – Daily Engagement (30 min per day): Participants were encouraged to use the system at least once per day to explore new sonic expressions of their culinary creations, reflecting on their experiences in preparation for the final dining session. After each use, they recorded their reflections, feedback, or insights either in written notes or audio recordings, which they shared with the research team via email or messaging apps. During this period, the researchers remained available to provide technical support and assist with any system-related issues. All the necessary materials are shown in Fig.11. During daily engagement, after each round of study, the researchers documented all sonic dishes created by the chefs for future analysis. However, these creation records were not deleted from the app and remained accessible in this shared

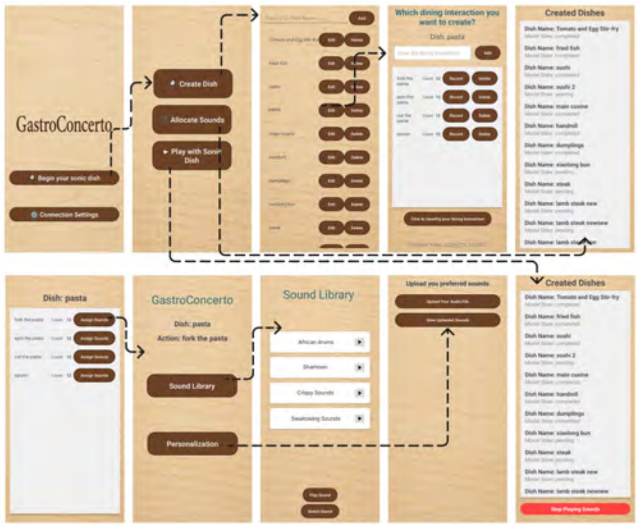

Figure 9: Overview of the application interface and interaction workflow.

Figure 10: Schematic flow of Study 2. Orange backgrounds indicate daily engagement activities, while pink backgrounds represent the dining session. (a) The researcher introduces and deploys the *GastroConcerto* at the chef's home. (b) Chef engages with *GastroConcerto* in daily culinary practice. (c) The chef prepares all materials before the dining session. (d) The chef serves and presents the sonic dish to the diner. (e) The researcher conducts a post-dining group interview with chefs and diners.

archive. This archive functioned as an open creative resource for subsequent chefs, who could reference prior creations to inspire new sonic dishes. We selected chefs' homes rather than restaurant settings for two reasons. First, *GastroConcerto* emphasized experimentation and iteration of sonic dishes by chefs themselves before official service, allowing them to perceive and develop culinary creativity within daily practice. Second, all participating chefs reported that conducting research activities during working hours in their restaurants was not permitted, making a home-based study the only feasible and valid option for this daily engagement process.

6.3.2 Dining Session. After completing the five-day engagement with *GastroConcerto*, a diner was invited to the chef's home for a dining session (approximately 60 minutes) to experience their final sonic dish creation. This session was structured into three phases: pre-dining, dining, and post-dining.

Pre-dining (15 min): Chefs prepared the dish and activated the *GastroConcerto* system in advance to ensure proper functionality.

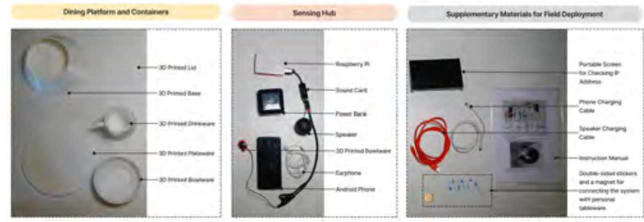

Figure 11: Study Material for Study 2.

Researchers then guided the diner into the chef's kitchen to be seated and arranged the dining table.

In-dining (10 min): Chefs introduced the underlying concept of their sonic dish. Once the dish was placed on the *GastroConcerto* system, the chef activated the corresponding entry from the app's creation list to enable sound responses during the diner's interaction. The diner was then encouraged to engage with and mindfully taste this dish. Open conversation and mutual questions between the chef and the diner were welcomed during this phase.

Post-dining (40 min): Both participants from the same session were invited to a semi-structured group interview to share their experiences. For chefs, topical questions focused on their day-to-day use of the *GastroConcerto* system, the creative process and experience and encountered challenges. For the diner, the questions explored their dining experience and any psychological or perceptual changes during the interaction.

6.4 Data Sources and Analysis

We employed a semi-structured interview method to gain in-depth insights into participants' thoughts, attitudes, and experiences through open-ended questions. Our primary dataset comprised notes, photos, videos, and recorded audio that were later transcribed. The application also recorded all sonic dish configurations throughout the study. In addition, we documented all creations by chefs, as well as notable observations and interactions during the dining sessions. We conducted a reflexive thematic analysis [8] using an open coding process to identify emerging concepts and themes with the aid of NVivo. Each question and its corresponding participant response were considered as a single data unit. Four researchers independently read the transcripts to become familiar with the data and then engaged in three rounds of reflective discussion to reach consensus on the coding. As a result, the findings were grouped into four distinct themes.

6.5 Findings

In this section, we present the four themes derived from the analysis of interview data collected during the five-day engagement and dining session with *GastroConcerto*. We also present six sonic dishes created by the chefs during the final dining session (Fig.12).

6.5.1 Theme 1: Translating Food Affordances into Sonic Expressions. This theme illustrates how chefs utilized the diverse affordances of foods (e.g., type, physical properties, cultural characteristics) to evolve *GastroConcerto*'s interactive mode from dining–sound pairings toward food–sound pairings.

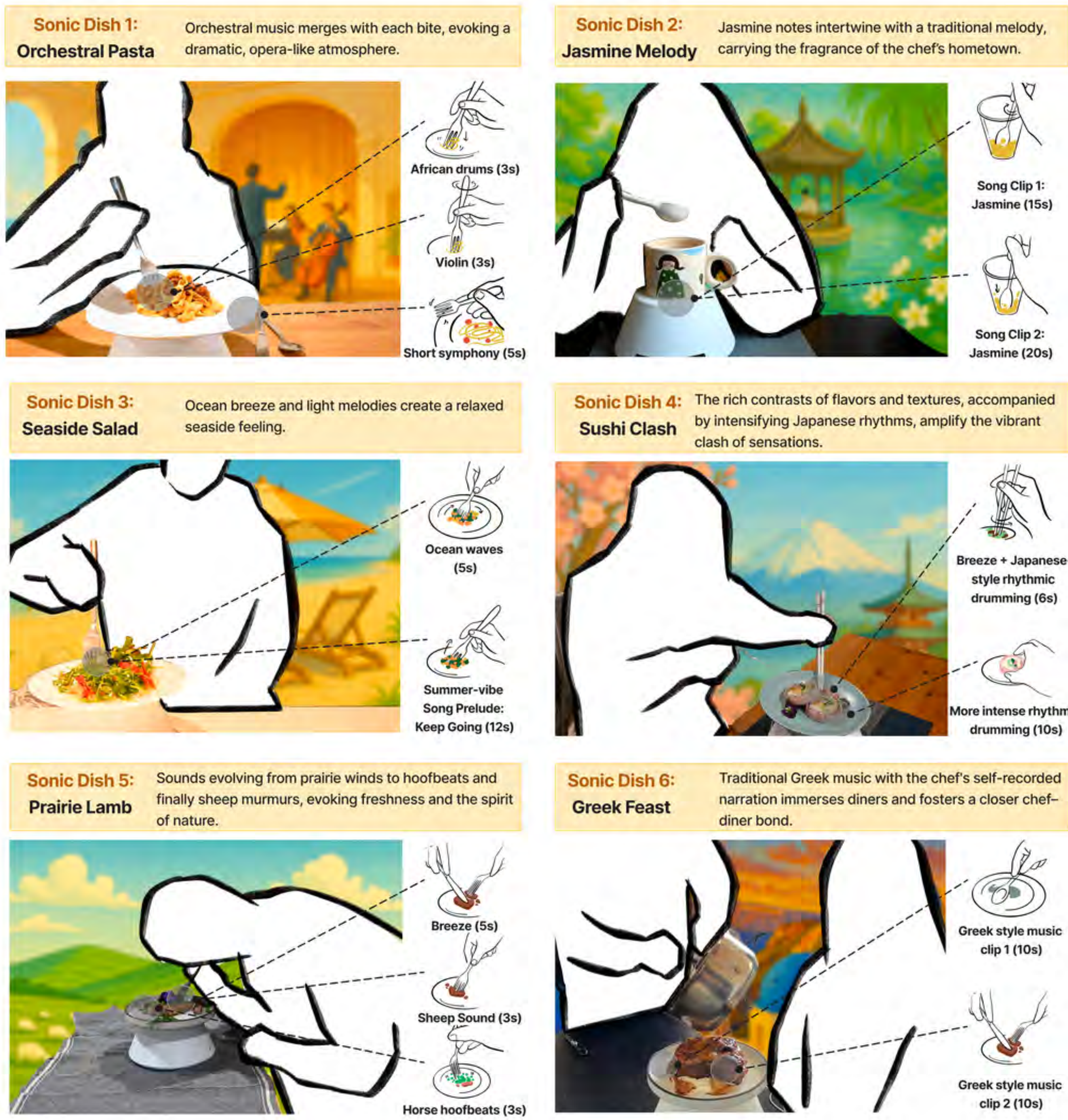

Figure 12: Demonstrating six sonic dishes, with hand-drawn illustrations showing how diners interact with each dish and the corresponding sounds below.

F1: Designing auditory interaction from ingestion conventions to enhance food expressiveness. Ingestion conventions refer to the established ways people consume particular foods [46], informing chefs in designing meaningful auditory interaction that enhances food expressiveness. For instance, C4 associated a wind-like sound with stirring wasabi into soy sauce, emphasizing its refreshing taste: "*The sound of wind feels like it belongs to wasabi [. . .] It's like coming from inside the food.*" D4 instinctively stirred the wasabi to trigger the effect, as only through stirring could the blended flavor be fully experienced. Similarly, C5 designed auditory interactions around the conventions of cutting and forking lamb chops, arranging the eating trajectory to evoke the ecological origin: "*I want diners to feel at ease at first. It's calming to hear a breeze when they start cutting the lamb. When they poke it, the feeling grows stronger [. . .] you can hear the communication of sheep across the grassland.*" These distinct dining patterns activated their sounds only when diners engaged with specific food states, reinforcing impressions of the dish. As D5 remarked: "*Chef connects the sound with the ingredients [. . .] they are bonded [. . .] It's not like a random sound.*"

F2: Assigning sounds from food metaphors to reinforce sonic associations. Chefs described how they considered the specific metaphors of foods (e.g., origin, culture, shape) when assigning sounds to strengthen diners' sensory associations. For instance, C6 paired traditional Greek music while slicing slow-cooked lamb, reinforcing the dish's cultural and regional identity (Sonic Dish 6). Similarly, C2 added jasmine honey at the bottom of milk tea. When diners stirred it, *GastroConcerto* released the culturally emblematic Chinese song (Sonic Dish 2). As D2 noted, "*This is a song I'm familiar with, it makes the jasmine tea feel more fragrant.*" These design choices resonate with cross-cultural research on sonic seasoning, which shows that cultural or symbolic sounds can shape how people interpret and emotionally engage with food [51]. Chefs further constructed associations through ecological metaphors. C3 linked poking smoked salmon to ocean sounds: "*It's seafood, I wanted to evoke that feeling of being by the ocean.*" This sub-theme highlights how chefs mapped sounds onto dining interactions through food metaphors, reinforcing diners' sensory and emotional connections with dishes.

F3: Harnessing variations in food properties for temporal sonic experiences. Some foods possess material properties that change over time or as they are consumed, allowing *GastroConcerto* to capture these transient transformations and create temporally situated sonic experiences. For example, C2 [Day 4] experimented with pouring alcoholic drinks, using the percussive acoustic signal of liquid striking glass to trigger sounds. Such sonic experiences, constructed in fleeting moments, seemed to blur the boundary between cooking and performance. Similarly, C2 explored shaking ice cubes, noting the effect disappeared as the ice melted: "*When the ice melts, the sound of the ice in the liquid becomes less noticeable. [. . .] Sound might only make sense at a certain moment, when a food has a very specific characteristic.*" This sub-theme demonstrates *GastroConcerto*'s capability to sense changes in food properties and thereby shape temporally evolving dining experiences.

6.5.2 Theme 2: Supporting Daily Sonic Dish Creation. *GastroConcerto*, together with its companion app, enables chefs not only to create daily sonic dishes but also to modulate various dining experiences through three key functional affordances.

F4: Aligning auditory interaction with culinary creation through instant experimentation. *GastroConcerto* enables chefs to experiment with and observe auditory effects instantly after creating a sonic dish, aligning with their ongoing creative vision. This capacity, on the one hand, supports short-cycle rehearsal. For example, C4 discovered that sound responses sometimes failed when crushing rice grains the night before the dining session, prompting him to remove the interaction for verification: "*I was really making sure those two sounds could be triggered properly before I presented it to the diner [. . .] otherwise it ruins their experience.*" On the other hand, instant experimentation also allowed chefs to iterate once an auditory interaction had been established. As C3 noted: "*I found that even with the same dish, I could create different atmospheres or moods by using different sounds.*" Lastly, C3 reported difficulties using the app during the creation process, noting that "*If the system could be designed a little simpler, it would help.*"

F5: Archiving sonic dishes for dining re-enactment through memory function. The memory function of *GastroConcerto* transforms past creations into creative assets that can be revisited during experimentation or dining. For example, C2 [Day 4] retrieved her Day 3 record, replacing a cocktail with orange coffee liquid to test whether the new drink could reproduce the same sounds: "*Once the setup is completed, you don't need to change everything each time [. . .] because it remembers all my settings. It's like binding the dish to the phone.*" The function also repurposed other chefs' records as shared creative assets. C3, for instance, drew inspiration from C1's earlier creations for new auditory interaction (Both of them used the 3D-printed plate). Across the five-day engagement, the memory capability enabled chefs to diverge, converge, and refine their ideal dishes (C1, C5, C6). As C1 reflected: "*These five days were like putting together a puzzle, bit by bit, completing a full creation. [. . .] On the last day, it really became part of my cooking [. . .] and the final result was worth it.*" This sub-theme reveals how memory enables long-term accumulation, fostering culinary refinement and dining re-enactment.

F6: Adjusting sound duration to modulate experiences across dining stages. *GastroConcerto* responds to auditory interactions on the plate, allowing chefs to adjust sound duration so the experience can span pre-eating, eating, or the entire meal. For instance, C5 tested a hen sound (2s) with jelly beans falling onto the plate [Day 2]: "*It was like the jelly bean was like an egg [. . .] falling onto the plate.*" This shows how short sound effects can animate food with a sense of vitality. In contrast, C1 used longer durations to maintain continuity in the dining experience: "*I found that not every interaction triggers a sound. So I chose fewer interactions and instead used longer sounds to fill the quiet gaps.*" Interestingly, digital sounds could also synchronize with the internal sounds of chewing to enhance food's multisensory qualities. As C4 noted: "*The sound starts playing from the moment the diner picks it up and lasts for a while. [. . .] When you chew it, you can still hear the crispiness of the fried food inside and the sound I selected for diners. These two kinds of sounds work together to create a unique experience.*" Together, these reflections suggest that *GastroConcerto* enables chefs to adjust sound duration to modulate the multisensory dining experience across different stages of a meal.

6.5.3 Theme 3: Transforming Culinary Awareness through Daily Engagement. This theme illustrates how *GastroConcerto* fostered chefs' culinary awareness throughout the five-day engagement, across three key aspects.

F7: Seeking musical inspiration for sonic dish creations. *GastroConcerto* introduced a new auditory layer, yet some chefs (C1, C4, C5) expressed concerns about their limited musical background. In response, they engaged themselves in a musical environment for inspirations. For example, C2 switched her music player to shuffle mode and recalled: "*Last night [Day 3] I heard 'city pop' on my way home [...] so I created a cocktail with a gradient look. It gave me a sunset vibe [...] and when paired with city pop music, it felt really nice.*" Similarly, C3 described listening to multiple musical intros before selecting pairings: "*I would think about what kind of food might match the song [...] then go to the market to buy foods that best fit the music.*" In addition, some chefs proactively sought assistance from the researchers, which stimulated awareness of interdisciplinary collaboration: "*Choosing sounds is the hardest part for me [...] it would help to talk with someone who has a music background like you [referring to the researcher].*" This sub-theme highlights how integrating auditory interaction into chefs' daily culinary practices reshapes their creative culinary habits.

F8: Reinvigorating culinary innovation through sonic practice. C3 described how the system encouraged more frequent reflection on creative ideas: "*I thought about it every day, how to match the music with my dish.*" In addition, chefs emphasized how the system motivated them to move from passive imagination to active creation. C5 explained: "*[Last time I created a new dish] was about two or three weeks ago. I was just looking at online recipes and thinking about how to adapt them. [...] But with this system, it's a different experience rather than just imagining. Now I actually start making the dish.*" Finally, chefs reported that this process expanded their creative vision beyond taste. As C1 reflected: "*It makes your imagination come true. As a chef, [...] it might be hard to express with just flavor or smell, but you can show it with sound now.*" However, C3 also noted that the dining–sound pairing mechanism cannot represent all his culinary vision, "*When you scoop soup with a spoon, it might not touch the bowl to make sounds [that the system can capture]. [...] So maybe only a few basic actions can be designed, like scratching or mixing [for this dish].*" This sub-theme shows how engaging with *GastroConcerto* reinvigorated chefs' awareness of innovation as a continuous and intentional process.

F9: Shifting from food craft to experience design. Chefs described a shift from previously focusing only on making delicious food to beginning to construct dining experiences for diners. C3 stated: "*I started from what I wanted to convey and the feeling I wanted to create [...] for the people who would eat it.*" Therefore, most chefs utilized various auditory interactions to weave culinary narratives rather than presenting isolated dishes. For example, C4 described his dish: "*When you start stirring [the wasabi], it begins with the calm sound of wind and gradually grows stronger [...] When the diner picks up the hand roll and puts it in her mouth, that's when the peak of the experience bursts out [...] It creates ups and downs throughout the dining experience.*" This sub-theme captures how chefs' creative thinking shifted from solely crafting food to designing multisensory dining experiences.

6.5.4 Theme 4: Facilitating Mindful Dining through Auditory Interaction. *GastroConcerto* enables diners to trigger auditory responses through active food interactions, embedding sound properties into dishes. These sonic properties serve as novel culinary resources for chefs to orchestrate while also fostering mindful dining experiences for diners.

F10: Heightening Awareness of Food. Several diners (D2, D3, D4, D5) appreciated how *GastroConcerto* heightened their attention to food instead of eating absentmindedly. D5 explained: "*If you eat while playing with your phone or doing something else, you actually ignore the dish itself.*" Meanwhile, the distinct localization of sound experiences also influenced diners' attentive engagement with food. D3, who enjoyed the speaker mode, commented: "*This sound came from in front of me, and it felt like my dish was making the sound.*" Meanwhile, D3 emphasized the importance of sense of agency in the sonic dish experience, noting that, "*If there's a sound I don't like, I think I should avoid the action that triggers it. Otherwise, it's annoying that you have to eat it with the sounds you dislike.*" In addition, D5 shared that the relatively low volume of the music played through the speaker made her lean in and listen more carefully, which in turn prompted her to observe the food more closely. In contrast, the earphone condition created a more intimate and direct experience. As D6 explained: "*When you wear headphones, you are isolated from outside sounds. [...] It gives you a clearer feeling of the information being conveyed.*" Beyond sound itself, participants (C1, D5) emphasized that the device's elevated size changed their visual vantage point, making it easier to observe and appreciate their food. As D6 noted, "*It lifts the food closer to you. [...] It made me pay more attention to this dish.*" This sub-theme illustrates how diners experienced a shift from distracted eating toward a more mindful awareness of food.

F11: Slowing Down to Savor Each Bite. D3, who self-reported that he usually ate quickly and sometimes ignored flavor, noted that sounds extended his chewing time and stimulated his appetite: "*The sound makes me feel like it's extending my chewing time. I will deliberately [...] keep chewing and then match the length of the sound. [...] I have a desire to eat it and savor the taste carefully.*" Similarly, D4 described how sound slowed down and altered her dining behavior: "*I started to think about the state the wasabi was in. I used to just dip and eat, without thinking. But now I notice how the green of the wasabi fades as I stir, and the particles move in the soy sauce like a liquid. So when I eat it, I stir it more evenly.*" This sub-theme highlights how sound encourages diners to slow their eating pace and savor each bite more attentively.

F12: Fostering Self-Emotional Awareness. D4 described how pairing wasabi with the sound of wind prompted her deeper sensory associations with the ingredient: "*It reminded me of a forest feeling. When I was stirring it, I imagined the fluidity of the wind, and I felt like the wasabi had that kind of fluidity at this moment.*" Similarly, D5 reported that the sound of sheep howling when she forking the lamb evoked a sense of empathy toward food: "*I feel sound will actually guide my thoughts. [...] With the sounds repeating, I start thinking more deeply, such as imagining this sheep running happily and naturally before it dies.*" This sub-theme demonstrates how *GastroConcerto* encourages diners to reflect on their own emotional responses during meals.

F13: Enhancing Chef–Diner Connectedness. C6 spread yogurt in front of diners to trigger his recorded narration of how he prepared the dish, creating a performative moment that evoked ceremony and intimacy. This made D6 feel genuinely cared for: "*I always [...] look a certain way or nod [to the waiter], but I felt I didn't need to do that in this experience. [...] It made me notice more details. [...] When I heard his voice, I felt even closer to him.*" D3 echoed this sense of connection: "*It makes me want to communicate with chefs more. Because you are eating their food, you will want to know* *why they added these sounds and how they cooked.*" This sub-theme reveals how the *GastroConcerto* experiences closely linked chefs and diners.

7 Discussion

From the above insights, while participants expressed positive experience about *GastroConcerto*, the new culinary consideration of sonic food creation also posed several challenges for chefs. For instance, it might disrupt dining experiences that chefs previously considered ideal, and a lack of musical background made it difficult for some chefs to establish meaningful connections between sound and food. In addressing these challenges, and by interpreting the findings from both studies alongside the development process of *GastroConcerto*, we present four design implications to inform future systems that support culinary creativity in crafting digital food.

7.1 Interpretation of Study 1

In Study 1, we found that the dining–sound pairing mode in the *GastroConcerto* system enabled chefs to engage with auditory interactions in a more enjoyable way, allowing them to explore and express deeper aspects of their culinary creativity. At the same time, the pairing mode is a multi-step creation process, requiring chefs to identify dining interactions, collect data, and assign sounds. This led to significantly longer creation durations compared to the sequential sound playback mode, and such extraneous cognitive load may have encroached upon the chefs' immersive flow during the creative process [63]. Nevertheless, granting chefs autonomy to design auditory interactions increased their efforts, thereby significantly enhancing their perceived worth of the final results once achieved [32].

Behavioral data collected during the evaluation revealed that chefs in the pairing mode adopted a more cautious attitude toward auditory interaction design. Interestingly, despite this cautious approach, the pairing mode fostered significantly longer and more frequent interactions with their dishes. However, no significant difference was observed in the number of sound responses between the two modes. This may be attributed to a system mechanism implemented in this study: dining interactions performed during sound playback were intentionally ignored to prevent overwriting or interrupting ongoing audio. As a result, when filtering out interactions that occurred during playback, the actual number of dining interactions used to trigger sounds did not significantly differ between modes. This design appeared to lead to a more balanced integration between auditory experiences and dining interactions. *GastroConcerto* enabled chefs not only to select sounds but also to consider their modes of interaction. This intentional constraint in the creative process, in turn, encouraged them to explore deeper and more meaningful forms of sonic dish creation [3, 61].

Meanwhile, *GastroConcerto* was designed to filter out irrelevant dining interactions during meals through both physical (e.g., a silicone pad was integrated beneath the platform and contact microphones were used to isolate vibrations from the table and surrounding air) and algorithmic (e.g., normalized entropy computation was incorporated) means to further distinguish meaningful signals. These strategies occasionally led to non-responses to pairing-related interactions. Nevertheless, most triggered sounds accurately corresponded to the intended dining interactions.

Finally, in food design, chefs often highlight the characteristics of main ingredients to shape multisensory dining experiences [55]. Therefore, analysis of the chefs' qualitative data revealed that sound can accentuate ingredient qualities or reinforce narrative expression, echoing prior HFI research that emphasized how digital content can endow food with expressiveness [10, 17, 73], and enabling chefs to connect with diners in more meaningful ways. Compared to sequential sound playback, however, the pairing mode triggered sounds through specific dining interactions, emphasizing the coupling of sound with food materials. This positioned auditory interaction as a configurable property of food to support culinary creativity, rather than a randomly presented element.

7.2 Interpretation of Study 2

This section demonstrates how chefs engaged in daily practices with *GastroConcerto*, showcasing its role in enhancing the sonic expressiveness of food, providing temporal support in culinary creation, and fostering mindful dining experiences for diners. Building on these insights, we propose four design implications for designers interested in developing digital interfaces that support chefs' culinary creativity.

7.2.1 Empowering Food with Sonic Expressiveness through Dining–Sound Pairings. This theme emphasizes how *GastroConcerto* endows food with sonic properties that chefs can further orchestrate to express their culinary creativity. Our data revealed that chefs designed unique dining–sound pairings, such as twisting pasta accompanied by drum sounds (Sonic Dish 1) or mixing salad with ocean sounds (Sonic Dish 3), to construct auditory narratives (F9). This dining-driven interaction resonates with prior sound-related HFI research, where licking interactions were employed to advance chefs' auditory expression [73]. However, different foods, varying in type and form, offered distinct affordances that shaped how they were consumed [42], resulting in unique dining patterns that ensured sounds were activated only when diners engaged with specific ingredients within a dish, thereby extending this approach. This can be explained through two aspects: (1) **Variation in dining interactions**: Eating different foods, or the same food in different states, subconsciously alters how diners perform dining interactions. For example, cutting a whole lamb with a knife and then lifting a lamb cube piece with a fork requires distinct interaction patterns (F2, sonic dish 5). (2) **Variation in sound signals**: Even when performing the same dining interaction, differences in food properties yield divergent sound signals (e.g., frequency, loudness, duration). For instance, shaking ice cubes taken directly from the freezer activates sounds, whereas once the ice melts, the same shaking no longer generates audible responses (F3).

The integration of auditory expressiveness into food properties stems from the computational capabilities of *GastroConcerto* to differentiate various dining interactions, enabling chefs to accurately and meaningfully present their culinary creativity with digital elements.

- **Design implication 1: Consider sensing the variations of food properties to enrich food expressiveness through**

digital representation. The dynamic properties of food materials, including physicochemical properties (e.g., electrical conductivity, thermal conductivity) and kinetic properties (e.g., biological deformation), have long served as important resources for designing dynamic interactive experiences in the HFI community [15, 64]. However, prior work has primarily emphasized food materials as outputs, whereas *GastroConcerto* extends this direction by computing variations in food properties as inputs, such as material movements (e.g., falling jelly beans (F6); pouring wine (F3)) and transformations (e.g., melting ice cubes (F3)). These diverse acoustic representations can be captured and computed by *GastroConcerto* to empower food creations with digital expressiveness, influencing how chefs construct dining experience. Therefore, we suggest that designers harness variations in food properties computationally to develop future interfaces by creating digital anchors in two ways: (1) Anchoring on specific foods within a dish to emphasize their culinary meaning through their affordances (e.g., texture, firmness); (2) Anchoring on the temporal characteristics of food (e.g., melting, dissolving, fermentation, evaporation) during consumption to shape dining experiences as they evolve over time.

7.2.2 Offering Temporal Support for Reflection in Chefs' Creative Practices. Our five-day engagement with *GastroConcerto* enabled chefs to develop new culinary routines (F7) and fostered an awareness of innovation that encouraged active sonic dish experimentation (F8, F9). This daily engagement aligns with the theory of Practice-based Design Research [24, 70], which emphasizes generating insights and fostering culinary reflection through action in practice. In particular, the temporal support capabilities of *GastroConcerto* further confirm this theory: (1) **Instant Alignment**: resonating with "reflection-in-action", where chefs exercised autonomy in instantly creating and adjusting auditory interactions within their dishes during the creative process, ensuring that sound elements became part of their culinary vision (F4). (2) **Archival Continuity**: resonating with "reflection-on-action", where chefs accumulated daily rehearsals as creative assets, which could later be iterated upon and re-enacted during culinary creation and the dining process (F5).

However, extending beyond chefs' embodied creative experiences, the temporal support of *GastroConcerto* functioned as a scaffold for reflection by enabling practical knowledge to be captured, preserved, and re-utilized. This scaffolding challenges prior HFI research, where researchers often assumed responsibility for the digital authoring process [17], overlooking the potential of integrating digital elements into chefs' everyday culinary practice. Our five-day engagement further highlights that digital element–empowered food innovation is not achieved overnight, but rather emerges gradually through chefs' daily practice and sustained engagement.

- **Design Implication 2: Consider leveraging instant alignment to support coherence between culinary thinking and digital authoring.** Chefs' dish innovation typically spans from brainstorming (e.g., seeking sonic inspiration, F7) and repeated practice (F4) to formal presentation [60, 62]. Instant alignment shortens the delay between ideation and execution. Within the food craft process, instant alignment of digital authoring further enables digital elements to serve as configurable culinary materials that remain coherent with chefs' cognitive extensions. Designers could, on the one hand, provide chefs with accessible user interfaces to interact with the system, and on the other hand, adopt lightweight machine learning algorithms based on low-dimensional data modalities. This avoids reliance on approaches that require detailed annotation, substantial computation, and iterative deep learning pipelines, such as images and videos.
- **Design implication 3: Consider leveraging archival continuity to accumulate digital dishes as creative assets.** Archival continuity allows chefs to transform individual configurations into creative assets that remain reusable and can inform the resolution of similar problems in the future. From the engagement with *GastroConcerto*, we further suggest that designers could support chefs' culinary creativity in three aspects: (1) Reuse: enabling chefs to iteratively refine and adapt their past digital dishes. (2) Re-enactment: aligning digital dishes with standardized practices in food service and hospitality, thereby fostering a stable and consistent dining experience. (3) Sharing: establishing mechanisms for community exchange and collective practice, so that individual practices can be transformed into transferable collective knowledge.

7.2.3 Facilitating Mindful Dining by Challenging Dining Norms through Sonic Dish Play. Dining norms implicitly regulate etiquette and rules across cultures, prescribing how people should eat [45]. For instance, remaining silent during a tea ceremony is considered essential for preserving ritual harmony. In contrast, with *GastroConcerto*, our diners challenged the taboo of playing with food by triggering diverse audio responses through their dining interactions, which fostered mindful dining experiences (Theme 3) [35]. This finding corroborates the theory proposed by Ferran et al. [4], which advocates integrating playful elements into dining to stimulate more active and sensorial interactions with food. More importantly, *GastroConcerto* expands chefs' culinary design by constructing induced mediated associations [2] between diners' interactions with food and the corresponding sounds , thereby shaping more embodied dining experiences. For example, chefs can assign metaphorical meanings to dishes through sound (F2); modulating sound properties (e.g., variations in volume, sound duration) can influence diners' body movements (F10) and diners' perceptions of the food (F6). This insight leads us to reflect on how to broaden chefs' creative space by orchestrating digital elements to modulate diners' interoceptive experiences.

- **Design implication 4: Consider orchestrating digital properties to modulate diners' interoceptive experiences.** Interoceptive experiences refer to the subjective perception of internal bodily states, which can be further characterized by awareness (noticing internal signals), accuracy (matching perception with reality), and sensibility (perceived intensity) [23, 44]. As our findings suggest, chefs were able to indirectly modulate diners' interoceptive experiences by employing auditory cues. Therefore, designers could provide mediation interfaces that enable chefs to further orchestrate digital elements to facilitate mindful dining across three aspects: (1) **Awareness**: adjusting the rhythm of digital presentations or haptic feedback to help diners notice bodily signals such as heartbeat or respiration during meals, thereby fostering emotional engagement with food. (2) **Accuracy**: synchronizing digital cues with biofeedback, such as employing heartbeat signals to provide immersive and socially engaging dining experiences. (3) **Sensibility**: modulating parameters such as intensity or localization changes to influence the perceived strength of bodily sensations during dining, such as the warmth or brightness of light.

7.3 Limitations and Future Work

Our study has some limitations. Our current design centers all interactions on tableware, enabling *GastroConcerto* to capture and analyze specific dining actions and their corresponding sound responses. However, this approach may conflict with certain food properties or cultural practices in which dining does not rely on tableware, such as eating a muffin directly by hand, which may limit chefs' creative expression. Therefore, future research could explore modular electronic components, such as providing a generalizable toolkit, that can be assembled on various dining wares or even integrated with the human body to accommodate diverse food materials and dining habits, thereby better representing chefs' culinary creativity. Secondly, *GastroConcerto* is an exploratory work that investigates how dining–sound pairings contribute to chefs' culinary creativity. Although culinary creative intent is inherently closed to chefs' self-perception, we acknowledge the limitations and potential biases associated with self-assessment. To further strengthen the evaluation of culinary creativity, future work could incorporate third-party assessments by professional chefs or diners, providing a more comprehensive and objective understanding of culinary creativity in designing interactive digital dishes. Next, *GastroConcerto* functions as an open-ended creative tool that allows chefs to personalize their own dining–sound pairing datasets, aligning the auditory responses with their authentic culinary visions. We acknowledge that this process is time-consuming and makes consistent baseline evaluation difficult. Future work could develop pre-trained action profiles by curating typical dining interactions using our provided diningware, and explore unsupervised or self-supervised ML methods for automated action classification. Lastly, the implementation of *GastroConcerto* in our studies was limited to controlled dining contexts and small-group settings, leaving its feasibility for deployment in more diverse real-world environments (e.g., restaurant) still unclear. Thus, we developed a future-envisioned storyboard (Fig.13) illustrating its potential use across varying acoustic conditions, different types of restaurants, diverse background music settings, and varying group sizes.

Based on our study, we observed that *GastroConcerto* was well received by chefs working in casual and fine-dining contexts, where creative experimentation and novel dining experiences are valued. In contrast, this mode of creation is less compatible with fast-food environments, where efficiency is prioritized. For such settings, future systems could adjust the distribution of agency between chefs and diners. For example, AI-based music generation could establish a bidirectional channel during meals, enabling chefs and diners to co-construct sonic dining experiences. Such AI-driven co-creativity may also help bridge the expertise gap for chefs who have limited experience in sound curation. Additionally, *GastroConcerto* distinguishes between dining interactions based on materiality-dependent signal variations. Building on this, future sonic dining experiences could sonify physical interactions with different materials in the environment, allowing them to resonate with background music to create responsive dining atmospheres that enhance and modulate diners' experience, interaction, and perception.

Figure 13: (a) An individual diner interacting with *GastroConcerto* at home, listening through the speaker to a sonic dish configured remotely by a chef. (b) A group of familiar friends dining together in a private restaurant room, where playful commensality emerges as they interact with different sonic dishes. (c) A public space in restaurant with background music, where diners dynamically adjust between private and shared experiences using both headphones and speakers, the resulting sounds can harmonize with the ambient music.

8 Conclusion

This paper introduced *GastroConcerto*, an auditory dining system that empowers chefs to orchestrate dining–sound pairings as a novel medium for culinary creativity. Through its design and study, we demonstrated how auditory interactions can influence culinary creativity by enabling sonic expressions of food, supporting iteration in daily culinary practices, and facilitating mindful dining experiences for diners. We also offered design implications for sensing food properties, providing temporal support for creative reflection, and orchestrating digital elements to modulate diners' interoceptive experiences, thereby informing designers interested in developing digitally empowered systems for chefs' culinary practices. Overall, we envision auditory dining systems not only as tools for novelty but as sustainable platforms that enrich chefs' creative repertoires and foster new ways of engaging with food.

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A APPENDIX

Figure 14: The in-the-field photos show our tests of the Touch Screen, Capacitive Board, IMU, Geophone, and ContactMicrophone.

Table 4: Participant demographics in formative study.

Code (Age, Gender)	Occupation (Workplace)	Attitudinal Label	Food-related experience	Interactive technology-related experience
P1 (24, Male)	Bartender (Casual dining restaurant)	Mild	3 years of experience crafting unique cocktails	Frequently uses Apple Watch voice control to time the shaking process during cocktail preparation
P2 (32, Female)	Head chef (Fine-dining restaurant)	Positive	10 years of experience in fine dining, including providing personalized customer service and creating customized dishes	Operated a restaurant featuring interactive audio-visual performances before
P3 (26, Male)	Italian restaurant chef (Quick service restaurant)	Negative	2 years of experience in a western restaurant, involved in preparing pasta, pizza, and salads	Although not used in professional settings, had prior exposure to interactive machines in shopping malls, such as those used for making juice and cotton candy.
P4 (28, Male)	Barista (Casual dining restaurant)	Positive	8 years as a coffee shop owner, focused on coffee product development	Regularly uses automated coffee machines to adjust the grinding, extraction, and dosing of coffee beans.
P5 (27, Male)	Pastry chef (Casual dining restaurant)	Mild	7 years of bread and pastry making experience	Participated in user studies for HFI systems, engaging with 3D food printing technologies before
P6 (28, Female)	Barista (Casual dining restaurant)	Positive	2 years of experience in a coffee chain, including preparing coffee and serving customers	Regularly uses automated coffee machines to adjust the grinding, extraction, and dosing of coffee beans.
P7 (33, Male)	Baking and pastry chef (Casual dining restaurant)	Mild	10 years of pastry research and development experience, covering launching new products in stores and training employees	Habitually employs automated dough mixers to control humidity, duration, and temperature for crafting doughs with varying gluten strength

Table 5: Participant demographics in system development.

Pseudonym	Age	Gender	Occupation
Caleb	24	Female	Master's student
Ethan	24	Male	Master's student
Ryan	23	Male	Master's student
Jordan	24	Male	Master's student
Aria	22	Male	Undergraduate student
Lila	20	Female	Undergraduate student

Table 6: The demographics and creative outcomes of chefs under two conditions. Sound IDs: 1–Chatting in a Café, 2–Raining, 3–Bonfire, 4–Street Hawking, 5–Chopping, 6–Frying, 7–Stirring, 8–Pouring, 9–Chewing, 10–Eating Chips, 11–Licking, 12–Swallowing, 13–Chinese Flute, 14–African Drums, 15–Japanese Shamisen, 16–Arabic Music, 17–Laughing, 18–Screaming, 19–Farting, 20–Trumpet of Failure.

	Occupation (Workplace)	Food Ingredients	Sound Sequence	Dining Interactions (Paired Sound)
P1	Western Chef (Fine Dining)	Toast slices, diced tomato, diced cucumber, shredded cheese, crushed chips	13→15→16→1	Knife cutting toast slice (13); Fork stabbing food (1); Fork stirring food (6)
P2	Barista and Pastry Chef (Casual dining restaurant)	Toast slices, sliced sausage, tomato	1→6→12→17	Knife cutting food (1); Fork stabbing food (17)
P3	Barista (Casual dining restaurant)	Chips, diced cucumber, carrot sticks	16→14→2	Spoon crushing chips (10); Spoon lifting food (20); Spoon tapping plate (19)
P4	Baker (Casual dining restaurant)	Cracker, sliced sausage, cheese, cucumber, lettuces	17→18→10→14→16	Fork crushing cracker (18); Fork stirring food (6); Fork stabbing food (10); Fork sliding on the plate (17)
P5	Chef (Quick service restaurant)	Chips, diced cucumber, diced tomato	1→13→14	Hand crushing chips (10); Spoon lifting food (3)
P6	Restaurateur (Quick service restaurant)	Toast slices, carrot, lettuces, cucumber, tomato	4→10→12→17→1	Knife cutting food (6); Fork stabbing carrot (3); Fork lifting carrot (18)
P7	Bartender (Casual dining restaurant)	Chips, cheese, sliced sausage, tomato	14→16→5→6→3	Food dropping onto plate (17); Fork stabbing food (6)
P8	Bartender (Casual dining restaurant)	Cracker, cucumber, cheese, sliced sausage	16→10→9→3	Fork crushing cracker (16); Fork lifting food (9)
P9	Baker (Casual dining restaurant)	Lettuces, sliced sausage, tomato, cheese	9→8→16	Tomato dropping onto plate (16); Fork stabbing food (13)
P10	Bartender (Casual dining restaurant)	Chips, lettuces, tomato, cucumber	5→10→12→11	Fork stirring food (10); Fork crushing chips (5)
P11	Bartender (Casual dining restaurant)	Lettuces, cucumber sticks, carrot sticks, tomato slices	6→7→18→2→8	Knife cutting food (14); Fork stabbing food (11); Fork sliding on plate (7); Fork tapping plate (17)
P12	Restaurateur (Casual dining restaurant)	Lettuces, chips, tomato, carrot	14→5→4→17→13 →11	Knife cutting food (4); Fork–knife mixing food (3); Fork stabbing food (13)
P13	Bartender (Casual dining restaurant)	Cracker, cheese, sliced sausage	2→17→11→10→9	Fork crushing cracker (14); Fork lifting food (11); Fork stirring food (1)
P14	Restaurateur (Casual dining restaurant)	Lettuces, tomato, cucumber	16→9→5	Knife cutting food (2); Knife stabbing tomato (10); Knife stabbing cucumber (10); Knife stirring food (7)
P15	Restaurateur (Casual dining restaurant)	Lettuces, cheese, tomato, cucumber, sliced sausage	12→6→7→3→2	Fork stabbing food (7); Knife cutting sliced sausage (5); Fork lifting food (4)
P16	Church Restaurant Chef (Quick service restaurant)	Toast slices, cheese, sliced sausage, lettuces	1→5→6→7→8 →17→3→4	Fork stirring food (6); Fork sliding along plate edge (17); Fork lifting food (11); Fork stabbing food (1)