The Wizard of Taste: Demonstrating Multisensory Eating with Electrical Taste and Bone-conduction Auditory Seasoning

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Figure 1: A participant tasting three multisensory scenes: *happy*, *scary*, and *calming*

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Abstract

Research on electrical taste in Human–Computer Interaction (HCI) has expanded opportunities for perceptible digital dining augmentations that become apparent only after ingestion. Electrical taste stimulation can evoke sensations such as sourness and saltiness,

but its perceptual range remains limited. Meanwhile, auditory seasoning leverages crossmodal correspondences to modulate taste experiences through sound, suggesting opportunities for dining augmentation. To extend multisensory eating interactions, we present a spoon-based interface, "The Wizard of Taste", that combines electrical taste stimulation with auditory seasoning. To ensure ingestion-contingent augmentation, we employ bone conduction so that electrical taste and sound become perceptible primarily when the spoon is in the mouth. We demonstrate this approach through three scenes—*happy*, *scary*, and *calming*—each paired with a classic Spanish food item (churros, chocolate, and flan). These scenes aim to illustrate how integrating electrical taste and bone-conduction audio can create engaging, playful, and private dining experiences.

CCS Concepts

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

Keywords

Human-Food Interaction, Electrical Taste, Auditory Interface

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1 Introduction and Related Works

Human–Food Interaction (HFI) [4–6, 16], an emerging subfield of Human–Computer Interaction (HCI), has explored how digital technologies can enrich dining experiences. In particular, HFI research investigated how digital stimuli can be synchronized with eating actions to modulate sensory perception, such as olfaction [2], taste [13], sound [21, 22], haptics [11, 12], and vision [15]. However, many existing interactive augmentations operate as ambient layers, making it difficult to precisely align stimulation with the moments of ingestion, such as when food enters the mouth and chewing begins. These ingestion moments play an important role in shaping flavor. Therefore, recent research has begun to explore the augmentation of bite-level eating experiences, which refers to adjusting diners' perceptions through digital stimuli across different phases of food intake (e.g., taking a bite, chewing, and swallowing). For example, prior work has applied electrical stimulation on the tongue when taking a bite to modulate specific taste dimensions [18, 19].

Electrical taste applies microcurrent stimulation to the tongue to evoke taste-like sensations [7]. While it can modulate perceived intensity and quality, its perceptual range remains limited, typically producing salty, sour, or tingling sensations [3]. Prior work has therefore integrated electrical taste into broader multisensory dining experiences, for example, by combining electrical stimulation with visual and thermal cues to create blended illusory taste experiences [17]. Electrical stimulation has also been explored to produce spatially and temporally varying tactile sensations [14], suggesting opportunities to combine electrical taste with electrotactile effects to enrich eating experiences. In parallel, crossmodal research has shown that auditory cues during eating influence perceived taste and texture, thereby reshaping diners' food experiences [8]. For instance, simple sound manipulations (e.g., amplifying the crispness of a potato chip) can augment perceived freshness and texture [9]. Building on these findings, we integrate sound as an ingestion-contingent channel with electrical taste, augmenting eating to be a more immersive dining experience. To capture sensations specific to ingestion, we use bone-conduction audio, which is perceptible primarily when the utensil contacts the oral cavity and remains largely imperceptible in air. This property enables sound and electrical taste to be delivered as an intimate, private, and ingestion-contingent multisensory augmentation.

Thus, we present "The Wizard of Taste", a spoon-based system that combines electrical taste stimulation with bone-conduction audio. The system features three engagement scenes—*Happy*, *Scary*, and *Calming*—each paired with a classic Spanish food, enabling a culturally grounded demonstration that is quick to experience in an exhibition setting.

2 Demo System

In this section, we describe the hardware setup and explain how we implemented electrical taste and auditory seasoning.

2.1 Hardware Design

The hardware system integrates auditory feedback and electrical taste stimulation to enable ingestion-contingent multisensory modulation (Fig. 2). It uses an ESP32-S3 development board, connected to a bone-conduction transducer via a MAX98357A audio amplifier. The transducer is mounted at the rear end of a stainless-steel spoon to enable effective sound transmission when the user's teeth contact the spoon. In parallel, electrical taste stimulation is delivered through gold-plated electrodes fabricated on a flexible printed circuit (FPC) and attached to the back of the spoon. When the electrodes establish sufficient contact with the tongue, users perceive controlled electrical taste sensations.

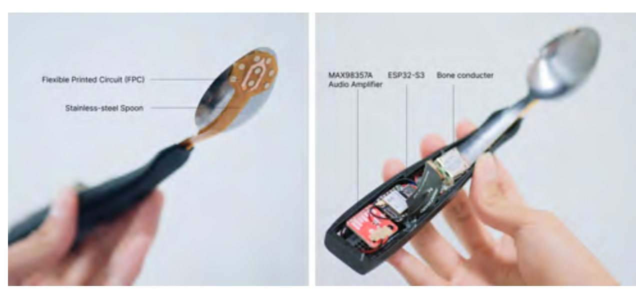

Figure 2: Annotated diagram of the system hardware: ESP32-S3 controller, MAX98357A audio amplifier, bone-conduction transducer mounted on the spoon's handle, and gold-plated electrode array with a dedicated return (ground) electrode.

2.2 Electrical Taste Seasoning

We parameterized electrical taste seasoning by current amplitude (μA), frequency (Hz), and duty cycle. The stimulation is kept within a comfortable intensity, below 180 μA. This cap is consistent with reported digital taste demonstrations that map 120 μA to sour-like sensations and 40 μA to salty-like sensations. We implemented a set of PWM-controlled stimulation patterns with constrained current magnitudes, frequencies, and duty cycles, delivered through the gold-plated electrodes. In the *happy* scene, the demo evokes a sour taste at an average current amplitude of 120 μA, delivered as a 500 Hz pulse train to introduce a gentle, vibratory sensation without overwhelming the food's underlying taste. In the *scary* scene, the demo targets saltiness using 40–60 μA at 50 Hz, and provides a sparkling mouthfeel by presenting stimulation as intermittent bursts. The *calming* scene features a 20 μA current at 900 Hz to produce a smooth, continuous high-frequency buzzing sensation. Electrical taste and electrotactile stimulation are delivered through circular-shaped stimulation electrodes, positioned to contact the anterior tongue, paired with a return electrode (ground) to reduce local current density.

2.3 Auditory Seasoning

Recent research shows a significant connection between hearing and taste [1, 4, 10, 20]. Studies on auditory parameters demonstrate that the characteristics of a sound, such as its intensity, noisiness, and sharpness, can evoke different taste associations. Prior studies highlight notable traits: the sound associated with sweetness has the highest pitch among the five tastes, while that associated with bitterness has the lowest. We collaborated with professional composers to create background sounds that evoke associations with three basic tastes (*happy* with sweet, *scary* with sour, and *calming* with umami). To enhance the experience, we incorporated various artistic elements. For example, the sound designed for sourness includes the noise of a spoon scraping the bottom of a pot and the timbre of brass instruments to intensify the sourness. Similarly, the sound designed for umami integrates recordings of boiling broth and flowing liquid to evoke a rich, savory quality.

2.4 Safety and Hygiene

All food-contact surfaces (tabletop, utensils, device covers) are cleaned with detergent and then disinfected with 70% isopropyl alcohol (IPA) between participants. Food is pre-portioned into single-bite servings and handled with gloves to minimize cross-contamination. For electrical taste stimulation, multiple safeguards are implemented. Stimulation is delivered via a constant-current driver capped at 180 μA. Participants receive clear instructions before interacting with the system and may pause or withdraw at any time. At least one researcher continuously monitors participant comfort and guides the interaction. An emergency stop control allows immediate termination of stimulation if any discomfort occurs. Bone-conduction audio volume is maintained at a safe and comfortable level.

3 Interaction Design

In this section, we describe how food was selected and how electrical taste and auditory seasoning were choreographed to create three distinct multisensory scenes.

3.1 Multisensory eating experience

We present a multisensory eating augmentation system that combines electrical taste with auditory seasoning delivered via bone-conduction audio. These digital stimulations are applied as coordinated overlays that modulate attention, contrast, and emotional tone, creating a sensory anchor with food in each scene. In the *happy* scene, the experience is grounded in sweet, fluffy churros. We introduce a sour electrical-taste overlay and pair it with a soft, rounded sound (BPM = 71; mid-frequency–dominant; lower spectral flatness), creating a playful crossmodal contrast that encourages a joyful, uplifting mood. In the *scary* scene, the experience is anchored by bitter, hard, dark chocolate. We augment it with a salty electrical taste overlay and sparkling electrotactile sensations, synchronized with a sharp, bright soundscape (BPM = 185; high-frequency–dominant; higher spectral flatness) to increase sensory intensity and perceptual sharpness. In the final *calming* scene, the experience is based on a smooth, milky Spanish flan. We provide a mild electrical taste overlay with a steady buzzing mouthfeel, paired with slow, mellow audio with a longer perceived decay (BPM = 148; low-frequency–dominant; lower spectral flatness). Together, these cues subtly enhance savory perception and produce a sustained, gentle sensation that aims to facilitate a relaxing experience.

3.2 Food Selection

For the food selection, we choose iconic Spanish dishes that are easy to source and prepare, ensuring the demonstration remains culturally grounded and practical to run on-site. Each scene is anchored by a distinct flavor–texture baseline that supports the multisensory augmentation. For the *happy* scene, we choose Spanish churros as a sweet base. Their thick and fluffy texture provides a mouthfeel that might align with a joyful atmosphere. For the *scary* scene, we select bitter, hard dark chocolate (85% cocoa), leveraging its pronounced bitterness and firm texture to create a tense sensory baseline. For the *calming* scene, we select Spanish flan, which offers a smooth, creamy texture and subtle sweetness, serving as a low-interference base that helps foreground the gentle high-frequency "buzzing" electrotaste and soothing audio.

4 Exhibition Setup

In this section, we explain how we set up the whole booth and how we implement the interactive demo process.

4.1 Booth Equipment

There is a poster in front of the booth area that describes the project and shows the food ingredients (Fig. 3). We use black curtains to enclose the booth area and reduce ambient visual distractions, creating a dark, immersive space that supports the emotional atmosphere of the three scenes. A table is placed at the center of the enclosed area, serving as the main interaction surface. On the table, we place three iPads as display screens, each playing a looping video (*happy*, *scary*, and *calming*) that provides visual context and guides participants' attention. To integrate the screens into the dining setup, we place a cover board with circular cutouts over the screens to expose visual contexts, resembling a plate. Each demonstration holds a single bite-sized portion of the corresponding food (e.g., churros for *happy*, dark chocolate for *scary*, and Spanish flan for *calming*). All

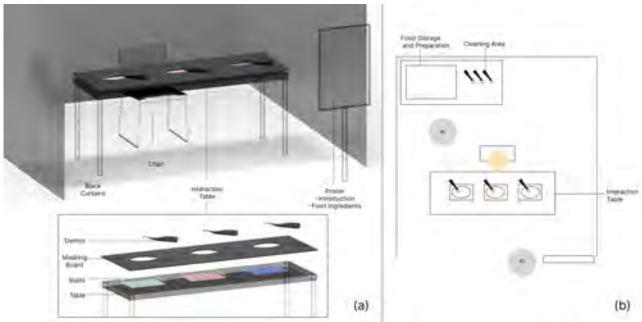

Figure 3: (a) 3D model of the booth layout, showing the curtained enclosure and the interaction table with three demonstrations. (b) Top view of booth setup.

foods are pre-cut into single-bite pieces to minimize mess, support hygiene, and enable rapid turnover in a walk-up demonstration setting.

4.2 Experience Flow

Participants are invited to enter the booth and sit at the interaction table. Upon arrival, one researcher provides a brief overview, describes the ingredients used in each scene, and confirms dietary restrictions and allergies before proceeding (~1 minute). The demo then proceeds through three emotional scenes, each pairing a dish base with synchronized electrical taste and audio. For each scene, the participant uses the system to take a single bite of the dish while the system delivers the matched electrical stimulation and auditory feedback (~3 minutes total).

4.3 Staffing Plan

We have at least two researchers staffing the exhibition at all times. One researcher is the experience facilitator, responsible for welcoming participants, explaining the demonstration, confirming eligibility (including allergies and comfort), and guiding participants through the three scenes. The other researcher serves as the system and hygiene operator, responsible for preparing food, sanitizing surfaces and devices between participants, monitoring the electrical stimulation controller, and preparing for the next diner. This division of roles supports queue management and ensures that safety and hygiene procedures are consistently followed.

4.4 Implementation

We bring at least six units to ensure continuous operation: three are on the tables for participant use, while three are rotated for charging, cleaning, and system checks to minimize waiting time. For hygiene, we sanitize demonstrations between participants using alcohol-based wipes/sprays and a portable UV sterilization cabinet (e.g., handles and electrode array surfaces), following conference guidelines and using single-use or replaceable items where appropriate. The booth setup includes three iPads (one per scene) with chargers and adapters, a custom masking platform (cover board with circular cutouts) to present the screens as "digital plates," and black curtains to create an enclosed, immersive environment. We also bring consumables for rapid reset and safe handling (waste bags, paper towels/napkins, gloves). Food is purchased locally in Barcelona; we select widely available, iconic Spanish food that are easy to portion into single-bite servings for consistent delivery. Food is stored in a portable refrigerator and kept at an appropriate serving condition using a heating pad in the preparation area. We coordinate with conference organizers and comply with venue policies on food handling, storage, and electrical equipment.

5 Discussion and Conclusion

Our demo presents a multisensory eating experience that foregrounds the user experience. By integrating electrical taste with bone-conduction audio in an interactive utensil, the demo enables CHI attendees to experience how these digital stimuli delivered at the moment of ingestion alter the perceived taste and dining experience. This aligns with the track's emphasis on clearly communicating the technical novelty and interaction experience in an exhibition setting.

Beyond the immediate audience, this work speaks to CHI subcommunities in Human–Food Interaction [16], multisensory interaction, tangible interfaces, and affective experience design. Our system combines (1) in-mouth audio via bone conduction for private, ingestion-contingent auditory cues and (2) electrical taste used not only for taste qualities but also for texture-like mouthfeel augmentation (e.g., subtle vibration, sparkling, buzzing). For the broader CHI community, we provide an on-site demonstration of augmenting real food with multisensory technology: The combination of digital taste and auditory seasoning expands the expressive range of eating augmentation and enables three emotionally distinct, repeatable, quick-to-experience sensory scenes (*happy*, *scary*, and *calming*). Finally, the demonstration functions as a design probe for future multisensory eating systems, inviting reflection on temporal alignment, attention steering, and perceived agency during food intake.

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