

Toward Computational Design of Dynamic Culinary Experiences

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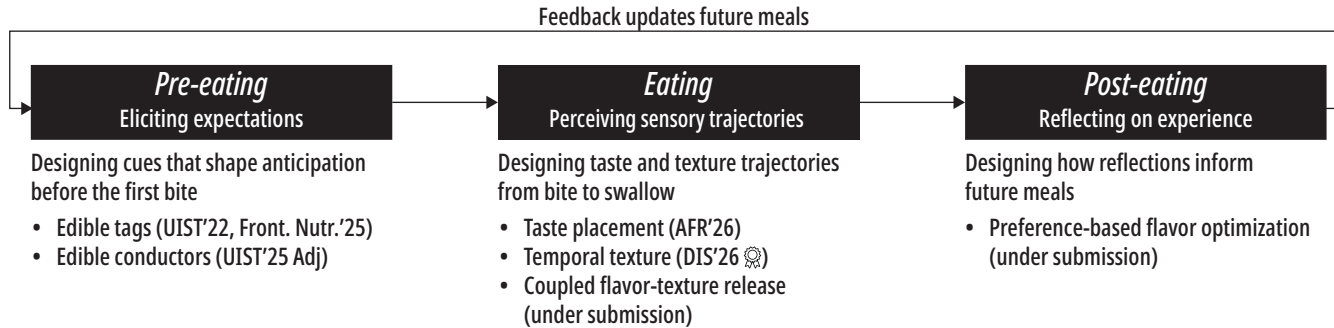


Figure 1: My dissertation frames computational food design as authoring how culinary experience unfolds across pre-eating anticipation, eating, and post-eating reflection, with feedback informing future authoring.

ABSTRACT

Eating unfolds over time: anticipation forms before the first bite, flavor and texture emerge through chewing, and post-tasting impressions can inform future meals. Computational food fabrication can precisely specify the physical properties of food, yet provides limited support for authoring how its perceptual experience unfolds through eating. My dissertation investigates how computational design can make these unfolding experiences authorable, creating dynamic culinary experiences whose anticipation, sensory progression, and reflection are designed as a connected whole. So that these experiences work in real dining settings, I embed the dynamics in food itself through fabrication, rather than in devices that diners wear or use while eating. My fabrication systems encode intended perceptual trajectories into physical properties of food: hidden structures control when information becomes available, spatial taste placement and internal geometry shape how flavor and texture unfold during eating, and post-tasting preferences update subsequent fabrication. Through further work on food-side responses before the first bite, post-eating experience, and an integrated authoring pipeline, I work toward dynamic culinary experiences in which anticipation, eating, and reflection can be specified, fabricated, and evaluated as connected temporal experiences.

KEYWORDS

human-food interaction, food fabrication, dynamic culinary experiences, temporal design, computational design, digital gastronomy

1 INTRODUCTION

Culinary experience is temporal. Before consumption, appearance, aroma, and context build anticipation that shapes how food will taste [20]. During consumption, flavor and texture are not fixed attributes but perceptual events that emerge through biting, chewing, mixing, and swallowing [18, 21]. After swallowing, memory

and preference carry the experience forward into future meals and food choices [4].

Making eating experiences designable is a central ambition of human-food interaction research [16]. Computational food design methods such as 3D food printing let designers program the shape, appearance, and texture of food with digital precision [15, 23], making the eating experience more predictable and reproducible. For example, recent systems choreograph food on the plate [1] or transform its shape during cooking [22]. In parallel with these fabrication systems, device-mediated augmentation influences taste and texture through techniques such as visual overlays, artificial taste stimulation, and sound feedback during chewing [5, 7, 17, 19]. Existing approaches, however, only partially support authoring how food experiences unfold. Fabrication systems can precisely program physical properties, but they less often connect intended perceptual trajectories to the physical structures that realize them. Device-mediated augmentation can dynamically alter sensory experience over time, but it relies on external instruments that may be difficult to integrate into ordinary dining settings shaped by cultural and social factors. What remains open, then, is to make unfolding perceptual experience authorable in food itself.

My dissertation addresses this gap. It centers on one question: *How can computational design make the unfolding perceptual experience of food authorable?* I use dynamic culinary experiences to describe food experiences whose perceptual qualities, information, and responses unfold through interaction over time (Figure 1). By *authorable*, I mean that designers can intentionally specify experiential goals, realize them through food fabrication, and assess whether the intended experiences emerge. To make such temporal authoring work in the practical context of eating, I mainly focus on fabrication techniques rather than relying on devices that diners wear or use while eating. I therefore build fabrication systems in

which designers author the temporal experience through fabrication parameters such as internal geometry, spatial placement of taste components, and material structure, and close the loop by updating flavor parameters from diners' feedback through machine learning.

In the following sections, I summarize my completed and ongoing systems along the eating timeline. My work is strongest in authoring sensory trajectories during eating. Timed information revelation before eating and preference-driven adaptation after tasting extend this core, while my remaining work strengthens the less developed pre- and post-eating phases and connects the three into a design space and evaluation methodology for temporal food authoring.

2 TIMING INFORMATION REVELATION THROUGH HIDDEN STRUCTURE INSIDE FOOD

My research began with a specific question: Can food itself carry information without disrupting how it looks and tastes? Food-related information (provenance, allergens, personalization, interactive content) is usually attached to packaging, menus, or screens, separating it from the food and constraining when and how it can appear to the diner.

interiqr (ACM UIST '22) embeds machine-readable tags *inside* 3D-printed food by modulating infill patterns, so that the visible surface and the eating experience remain intact while the tag can be decoded by backlight or interior imaging [13]. EateryTag (Frontiers in Nutrition '25) extends the same line across fabrication methods, studying the trade-off between detectability, concealability, and eating experience [10], and further work explored low-cost tagging for everyday foods [9] (Figure 2). Evaluations showed that embedded tags could remain concealed under ordinary viewing conditions and become machine-readable under backlighting, while a pilot tasting study found broadly similar eating experiences to an untagged control.

Within the dissertation, edible tags are an early case that motivated this authoring view: information is physically encoded in food and becomes available only under particular sensing conditions such as backlighting or interior imaging. This demonstrates conditional revelation rather than a continuous perceptual trajectory, shifting food information from a fixed surface label to a cue that unfolds through interaction. The remaining question is experimental: whether such delayed revelation changes anticipation, trust, or interpretation before the first bite. These structures also remain passive: they stage revelation but do not respond to the diner. Building on exploratory work on edible conductive gels (ACM UIST '25 Adjunct) [11], I am now investigating *food-side responses*, in which food itself responds to diners before the first bite (Section 5).

3 AUTHORIZING THE SENSORY TRAJECTORY OF EATING

This is the core of my dissertation: specifying a desired sensory progression and developing physical design handles that cause that progression to emerge through eating. Hidden structure can stage what diners expect, but a further question followed: Can fabrication control what diners perceive *while* they eat? Taste and

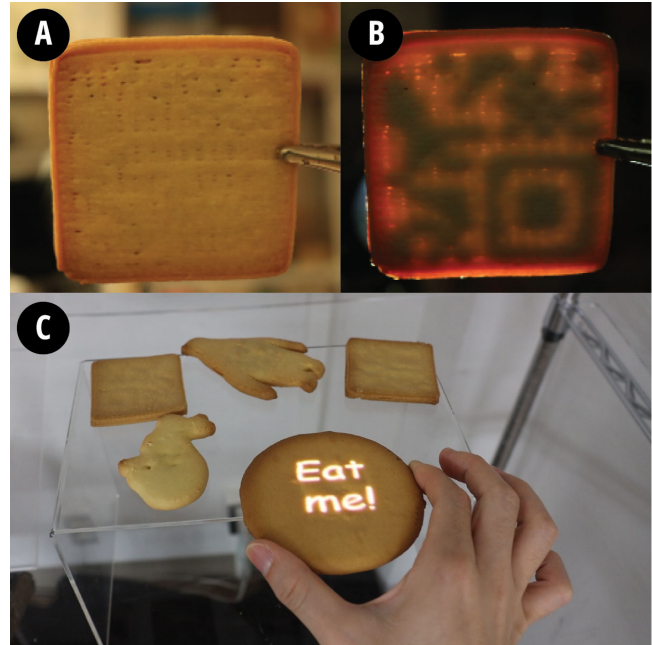


Figure 2: Timed information revelation through hidden structure inside food. (a) The food in its ordinary state. (b) Visualizing the embedded tag. (c) An example in which a revealed message prompts the user to select a food item.

texture are usually specified as recipe-level amounts (how salty, how hard), yet they are experienced as trajectories over oral processing. Prior work shows that fabricated internal structure can already shape perception, for example creating satiety illusions through infill patterns [6]. I develop fabrication techniques that go one step further and treat the trajectory itself as the authoring target.

3.1 TastePrint (Applied Food Research '26)

TastePrint separates food geometry from taste placement. A 3D food printer deposits a single base material while synchronized airbrushes apply liquid seasoning at programmed positions within each layer [12]. Technical evaluations established predictable control over spray footprint and deposited amount. In a small sensory study, centralized seasoning patterns tended to be perceived as more spatially localized than distributed patterns, although responses varied across participants. As a diner bites, cuts, and mixes the printed food, this placement becomes a way to influence when flavors are encountered during eating (Figure 3).

3.2 ChewTect (ACM DIS '26, Best Paper Honorable Mention)

ChewTect targets temporal texture through computationally designed molds. By varying infill density, pattern, and shell thickness in 3D-printed silicone molds, it creates food samples whose perceived hardness differs between the first bite and subsequent chewing [8, 14]. Because the molds are compatible with ordinary cooking, the approach keeps temporal texture design inside existing culinary practice rather than replacing it (Figure 4). A study with 27

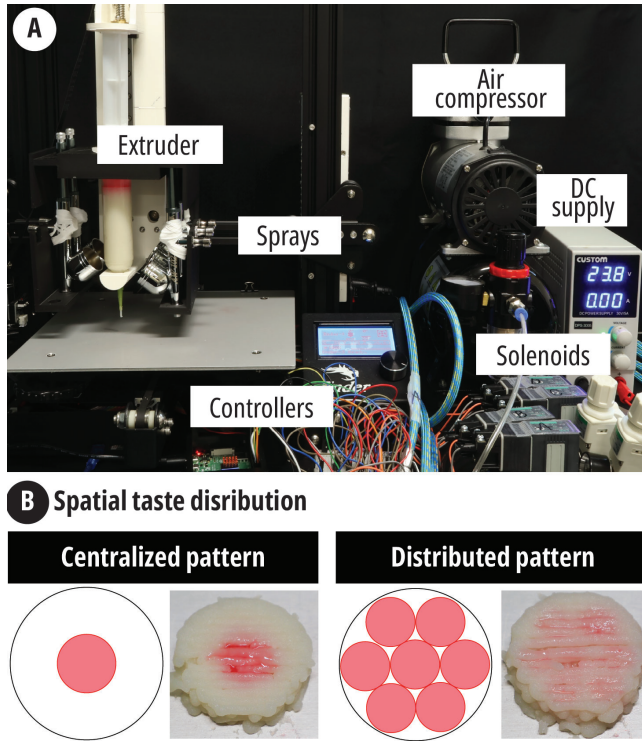


Figure 3: TastePrint system and spatial taste distribution. (a) A 3D food printer combines extrusion with synchronized seasoning sprays. **(b)** Different taste-placement patterns create centralized or distributed seasoning inside the printed food.

participants showed that infill pattern primarily affected first-bite hardness, while shell thickness affected hardness during chewing; infill density influenced both stages. Subjective ratings and masseter EMG showed corresponding trends, providing an empirical basis for mapping target texture stages to internal structure.

3.3 Coupling Texture and Flavor Release (under submission)

My most recent completed system unifies these two threads through edible metamaterial structures. The design combines structural regions that activate at different stages of compression, while simulation previews their relative activation order before fabrication. This staged compression coordinates texture progression and the order of flavor release within a single bite. The system has been evaluated through mechanical tests and a perceptual proof-of-concept, and the manuscript is under submission.

Together, these systems support the central premise of my dissertation: intended perceptual trajectories can be encoded into the physical structure and composition of food. Whether diners perceive the *intended* trajectory end to end is the target of my planned final evaluation (Section 5).

4 CLOSING THE LOOP FROM TASTING TO THE NEXT MEAL

Eating does not end at swallowing. The post-eating phase includes immediate judgments, reflection on the experience, and memories that may influence future meals. My current work addresses one concrete part of this phase: how immediate tasting preferences can shape what is fabricated next.

My work on human-in-the-loop flavor design closes this loop with preferential Bayesian optimization [3]. A closed-loop system fabricates edible samples, gathers preference judgments through tasting, and updates a model that proposes the next sample to fabricate (Figure 5).

The food domain adds a constraint often treated abstractly in preference optimization: each query carries a physical and sensory cost because it must be prepared and eaten. The framework therefore evaluates efficiency as the useful preference information obtained per edible sample, accounting for consumption alongside optimization iterations. This reframes post-tasting evaluation as a design input: each preference judgment updates the next fabrication cycle. This extends perceptual authoring from a one-shot mapping into an adaptive loop: tasting becomes feedback for updating the physical parameters of the next artifact. A manuscript on this system is complete and under submission. The current system addresses one part of post-eating: using immediate preferences to guide future fabrication. It does not yet address how lingering sensation, reflection, or memory develop after swallowing. Section 5 treats these as possible future design targets.

5 NEXT STEPS

I am currently in the second year of my doctoral program at Saitama University under the supervision of Prof. Parinya Punpongsonan, expecting to complete my dissertation in September 2027. Most of the systems above are published at UIST, DIS, and food-science venues; the two most recent are complete with manuscripts under submission. My remaining work develops three threads. Within this year, I will strengthen the pre- and post-eating parts of the framework through exploratory prototypes and studies. In the final year, I will consolidate the design space and conduct the final evaluation.

Strengthening the framework before and after eating. My completed pre-eating work supports timed revelation through hidden but passive structure. I next investigate how food itself can respond to diners before the first bite. Rather than treating food as a passive object, I explore food-side responses that shape how diners approach, select, and anticipate food while the food continues to be perceived as food. Here, response refers to a food-side change in detectable or perceivable state triggered by diner action, such as touch, proximity, moisture, or temperature. This extends pre-eating authoring from choosing when a cue is revealed to shaping how food reacts to the diner. I will organize this work around the relationship between triggering mechanisms, food-side responses, and the diner actions they invite. The evaluation will examine whether a response changes the diner’s expectation, interpretation, or next action before eating, beyond confirming that the food can physically change.

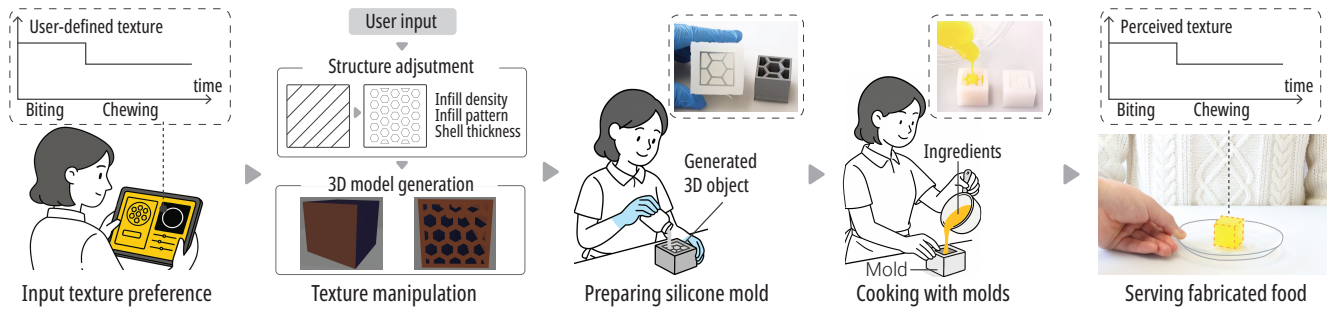


Figure 4: ChewText overview: a desired transition from biting to chewing is mapped to mold structures and ordinary cooking to produce a perceived texture trajectory.



Figure 5: Closed-loop flavor design workflow: the system prepares edible samples, collects tasting-based preference feedback, and uses that feedback to guide the next fabrication cycle.

In the post-eating phase, my current optimization work uses immediate preference judgments to update future fabrication. I next examine how the experience itself continues after swallowing. Possible targets include lingering taste, reflection soon after eating, and remembered experience after a delay. Exploratory work will identify a tractable target and examine how it can be represented as a temporal design goal or as input for future authoring.

A design space for temporal food authoring. Across these systems, a common authoring structure emerges: an intended experience is mapped to a physical design handle, encoded through fabrication, realized through embodied interaction, and evaluated through perception or feedback. I will consolidate these relationships into an explicit design space organized around four elements: the experiential target, the physical design handle used to realize it, the interaction or condition through which it unfolds, and the method used to evaluate the resulting experience. These elements take different forms across the eating timeline. Before eating, systems may hide or reveal cues or respond to diner actions; during eating, they may shape taste and texture trajectories; after eating, reflections and preferences may inform subsequent designs. Physical design handles include internal geometry, taste placement, responsive materials, and preference models. The design space will help designers connect intended experiences to realizable food structures, compare authoring strategies across phases of eating, and

identify gaps in how dynamic culinary experiences can be specified, fabricated, and evaluated, complementing experience-centered design spaces in human-food interaction [2].

An authoring pipeline for dynamic culinary experiences.

The final step of my dissertation is to integrate the individual systems into an authoring pipeline that connects experiential intention, fabrication parameters, and perceived eating experience. In this pipeline, designers specify experiential goals such as when information is revealed, when flavor emerges, how texture changes during chewing, or how post-eating experience should inform a later meal. The pipeline then maps these goals to appropriate design handles, including hidden structure, taste placement, internal geometry, responsive materials, and preference models. I will implement it as a set of authoring mappings, fabrication recipes, and small parameter-generation tools rather than as one monolithic system.

The final evaluation will ask whether intended experiential goals are successfully translated through authoring and fabrication into perceived experience. The dissertation will contribute an authoring framework, physical design handles for different phases of eating, and evaluation methods suited to their different time scales.

6 FEEDBACK SOUGHT AT THE DOCTORAL SYMPOSIUM

At the Doctoral Symposium, I seek feedback on two methodological questions. First, which pre- and post-eating phenomena are both meaningful and feasible targets for temporal authoring? My current candidates include food-side responses before eating and lingering sensation, reflection, or memory after eating.

Second, how should authoring success be evaluated across phases that operate on different time scales? During eating, intended and perceived sensory trajectories can be compared directly. Anticipation and post-eating reflection depend more strongly on context and time. I seek an evaluation approach that supports a coherent dissertation claim while preserving these differences.

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