Towards Edible Interfaces: Designing Interactions with Food

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ABSTRACT

Food provides humans with some of the most universal and rich sensory experiences possible. For a long time technology was unable to recreate such experiences but now new innovations are changing that. Using the novel manufacturing technology of 3D printed food, I am developing 'Edible Interfaces'. My research uses a user-centered research approach to focus on food as material for interactive experience in HCI. This will lead to development of Edible Interfaces that are built on the understanding and application of the experiential affordances of food. Designing with food allows the creation of forms of experience not possible through traditional interfaces. My studies so far have explored the perceptions of 3D printed food and potentials for food to advance affective computing. This knowledge is broadening on-going work in the field of multi-sensory HCI and delivering a new perspective on how we design for experience.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI) → Interaction devices**

KEYWORDS

Multi-sensory interaction; taste; user experience; taste experiences; sensory research; 3D printed food

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1 INTRODUCTION

Through emerging technologies, the possibility to touch, smell and taste in digital interactions is becoming a reality. This has given birth to a new field of study in Multisensory Human-Computer Interactions. The importance of this field is reflected in the recent success of commercial haptic technologies as part of a 'Material Turn' in interactions design [24]. My work is aiming to build on this shift towards increasing tangibility, by exploring how gustatory and olfactory sensation can be exploited to offer new opportunities for interaction designers. My research explores food, and related taste sensations, to understand how they can be unified with digital media to create novel and rich experiences. Food provides the platform for some of the most semiotically rich interactions that humans have created, from the primal nature of cooking over a fire, to the ritualistic baking, performance and consumption of a birthday cake. So how can we leverage these experiences for the development of multisensory HCI?

To answer this, I take the perspective of exploring food as a material, with the intention of extending the possibilities for interaction and experience in HCI. Thanks to my partnership with Dovetailed Ltd. who have developed a 3D food printer (nūfood [8]) I will be able to use 3D food printing to directly explore the design of 'Edible Interfaces'. Unlike previous work on HCI and food I am able to conduct research in-the-wild, to truly understand how food can bring new, meaningful and useful experiences into human-computer interactions. The aim of this research is to put food and taste sensation into an interaction designer's toolbox, opening up new experiential territories to explore in interface design. My work sits in the field multisensory HCI and draws from affective computing, embodied cognition and the psychology of taste and emotion to inform this new area of enquiry.

2 RESEARCH QUESTIONS

2.1 How can food be used to create novel experiences in HCI?

Food has been shown to have connections to both psychologically [26] and sociologically mediated experiences [6]. My hypothesis is that food can be used to create interactions that stimulate experiences that are unachievable through other modalities. One promising direction is aiding the development of affective computing through the mappings between taste and emotion [3]. Research in embodied cognition and psychology describe a series of such mappings; however, experimental research in this field has largely been confined to lab studies in which the taste stimulus is often a colorless water. This is far

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removed from a recognizable everyday taste experience that I am aiming to explore.

My research will test these lab-derived hypotheses in applied settings, exploring their relevance and importance for interaction designers. Beyond this, I will also explore how food challenges the way we think about experience, affording designers the opportunity to design for 'Metabolic Interaction' [31] considering the interplay of multimodal experiences through the lens of consuming food.

2.2 How can 3D printed food be utilized in multisensory interfaces?

One of the long-standing issues with developing taste and smell based interactions has been that they are chemical in nature, requiring an output device capable of producing a range of physical materials. 3D food printing is one possible solution, as it is capable of producing specific flavors on demand. Thus it offers the ability to design physical flavor stimulus into an interface design that connects digital content with a taste experience.

In this way, the technology demonstrates its potential as a computational material, bridging the gap between physical and digital contexts. This hybridity creates challenges in terms of its perception and acceptance by users. Through my research, I am exploring these issues and will use insights gained to contribute to the informed application of the technology within my future prototypes.

2.3 What design approaches are needed to create interactions with Edible Interfaces?

Through the research, development and design of Edible Interfaces it will be necessary to address which, if any, of the current approaches are useful for designing Edible Interfaces. I will engage with theory and primary research into various food related practices to evaluate existing, and propose new, design approaches for creating experience with food.

3 RELATED WORK

3.1 Multisensory HCI

As both research and industry look beyond traditional interfaces, new knowledge is being sought in exploiting tactile, taste and smell sensation. It is searching for richer interactive experiences by building on the concepts of multisensory and cross modal psychology [28]. This work forms the field of multisensory HCI and is focused on scoping out new design spaces for, and identifying the challenges of, multisensory interactive media. It is concerned not with traditional problem-solving, but with the creation of new possibilities and opportunities for experience in interaction design [19].

Within HCI more broadly, food has provided a compelling subject for study in recent years. Comber et al. [5] and Choi et al. [4] both provide collections of projects that have exploited various spaces around food experience, in particular encouraging healthy behavior and sustainable practices. One common failing of the work to date is an inability to directly interact with food, with most projects focusing on locating technology around existing food situations instead. A good example of this is PhotoTalk, which places a digital photo frame as a conversational center piece for the dinner table [20]. Another critique of the existing research is that has focused too heavily on 'problem-solving' issues and has not, so far, explored the possibilities for 'Celebratory Practices' [14] building on the hedonic and experiential aspects of food. This perspective informs my own research focus on creating novel experiences beyond the dining table as I aim to extend the possibilities of HCI through an entwining of technology and food.

Latterly, the direct integration of taste experience into HCI is most extensively explored through 'digital taste' research [15]. This work eschews chemical means of stimulating taste and smell, to enable the exploration of taste sensation as part of digital interaction. The work uses electrical or thermal stimuli to replace the food stuff; enabling the construction of remote taste sharing applications [23], offering speculations on remote dining and taste-based communication systems [15]. However, the most promising work on taste experience in HCI has been carried out by Obrist et al. [18]. Through experimentation on the experiential qualities of the basic tastes they have created a series of diagrams that describe the 'temporal, affective and embodied characteristics' of each. Their approach brings together the diverse qualities of taste experience into descriptions of each taste's materiality, providing future designers with guidance as to how to work with these tastes to create specific experiences.

3.2 3D Printed Food

3D printing food is the application of additive manufacturing technology for the production of edible structures. Its properties have been cited as an ideal candidate for developing human-computer taste interfaces [15]. Initial interest in this technology, however, has been limited to extending creativity in the kitchen [13] through concepts such as 'Digital Gastronomy' [16]. Whilst this work highlights some of the disruptive potential of 3D printed food; exploring how the foodstuff can be used to mediate between digital and physical media, it stops short of considering how it can enable new situations for taste to be experienced. The properties of 3D printed food engage with aims of 'Computational Composites' [32]. This perspective proposes using materiality as lens to understand the fluid exchange between humans, objects and computers. Through the design development of Edible Interfaces the merits of such critical positions can be examined in more detail.

4 APPROACH AND METHODOLOGY

My approach relies on understanding the qualities of food experience, in order to apply them to designing novel interactions and interfaces. To collect my insights I will look to a range of disciplines including psychology, psycho-sociology and

gastrophysics [29] (the study of the multisensory perception of food), these topics offer a range of perspectives on food and taste experience, providing me with a broad spectrum of qualities to consider. The construction of this knowledge into design prototypes will involve the consideration of embodiment [1] and how it may influence the application of various aspects of food experience to HCI. Through this approach, I follow work by Gibson [12] and Dourish [22] in recognizing the importance of affordances for interaction design.

The methodology I will implement is built on a user-centered approach, starting with insight from interviews and surveys with potential and existing users of 3D printed food technology. Capturing their experience of this foodstuff is key and to do so I will call on methods demonstrated by Obrist et al. [18] in their multisensory HCI research. The insights gained from this will be fed through an iterative design prototyping process to form a series of experimental studies into Edible Interfaces. These will be progressively more situated, as I move towards the design, development and evaluation of in-the-wild scenarios. To initiate this process, procedure has been adapted from work by Wilson et al. [33] on thermal interfaces for affective experience. The development of these initial prototypes will be supported through co-design workshops in which both users and domain experts can shape the generation, provocation and evaluation of new ideas. The construction of functional interfaces prototypes is made possible by the nūfood 3D printer. This will act as a technology probe [30] to realize and implement Edible Interfaces in my research.

5 RESEARCH IN PROGRESS

5.1 Perception of 3D Printed Food

The first of my current studies sets out to discover perceptions of 3D printed food. Previous work into this technology has been centered around the possible application of 3D printed food [13,34] without considering the user's experience of, and attitudes towards it. My research will uncover such perceptions of 3D printed food, examining the various drivers and motivators that shape its use and acceptance by users. To do this I conducted a survey of early adopters; recruited through invitations to the nūfood printer's mailing list. 24 responses were collected with the sample group mostly male (17) with a high proportion holding a postgraduate degree or higher (13).

The survey captured general attitudes of the sample through the Food Technology Neophobia Scale [11] and the Social Representation of Food Scale [21]. Both validated scales have been developed to understand attitudes towards food and technology. Findings from these scales help identify which factors influence the perception, and potential acceptance, of 3D printed food. The survey also included open-ended questions on the experience and expectations of the technology. Risk and benefits were assessed according to factors highlighted in a meta-analysis of associated literature [2], this was applied at an overall level as well as towards specific stages of the food production process, through sourcing, to storage and consumption. Alongside these influencing factors, expected uses for the technology were explored to help understand how it is perceived in its functional context. Responses to these various topics where thematically coded to support further analysis.

Preliminary data gathering shows that the sample displays many of the common features of early adopter groups [25], with low Food Technology Neophobia [11] when compared to a population score, a high *Adherence to Technology* and a strong influence of *Enjoyment* on their representation of food [21].

The greatest expected use of 3D printed food was for experimentation, suggesting a dominance of the technology in how the food is understood. Decoration was the second most frequent use reported and indicates how the aesthetic qualities of 3D printed foods are expected to be the most important. Uses in which a nutrition value is found were seen less prominently, perhaps this is informed by most 3D printed food which is sugary or fatty and thus, has a low nutritional value. The most common reported context for eating the food was 'restaurants' and 'high-end', coupled with an absence of any domestic application this points to a technology that is not currently expected to be seen in a domestic setting. More extreme uses such as for 'space travel' suggest an expectation that this food technology is suitable for atypical food production contexts. This reinforces the modal 'experimentation' response that situates 3D printed food as a futuristic technology for the discovery of new foodstuffs and food practices rather than complementing existing ones.

The biggest perceived risks with 3D printed food were incorrect usage, contamination and misinformation. The prevalence of information related risks in these findings seems a logical response for a novel food technology. One solution to this anxiety over novel foods would be promoting reassuring information to a suspicious public. However, there have also been critics of this 'knowledge fix' approach [9] with positive experience being shown to be of greater influence in acceptance of food [17]. When compared with our preliminary findings from the social representation study [21] we can see that the early adopter sample is similarly suspicious to the given population but diverges greatly when it comes to enjoyment as a motivating factor for acceptance. This emerging trend will be explored through further work as the research continues.

These initial findings are being extending by including a range of user groups (reaching out to wider 3D print community and to technology and science students to provide a more general interest sample). In order to deepen this enquiry, I will also conduct semi-structured interviews that further explore the factors influencing perception, particularly with respect to some of the early findings uncovered in relation to risk.

5.2 Food / Emotion Mappings

One of the key qualities of the experience of food is its connection with emotions. Mappings between various tastes have been shown in experimental findings from psychology. Bitterness has been widely associated with negative experience [16,17,28,32], whilst sweetness has related to broadly positive

affective response [16,24,32,33]. The limitation of these studies has been they consider taste in an abstract lab-based context. To assess the potential for these mappings to be used in an applied scenario I am undertaking structured interviews with food industry professionals. Participants selected include chefs, but also food designers who work with food in more experiential and performative contexts.

The interviews explore two models of emotion classification for understanding the mappings. Interviewees are asked to describe tastes both in terms of Russell's Circumplex Model [27] and Ekman's classification of basic emotions [10]. Early findings suggest that the mappings for sweet and bitter as described in the psychology literature, do translate into applied contexts; however previously unreported mappings have emerged as well. Umami has been linked with comforting, affective response repeatedly whilst no tastes have been reported as conveying anger or sadness effectively, this has been shown by both mappings to basic emotions as well as from the circumplex models.

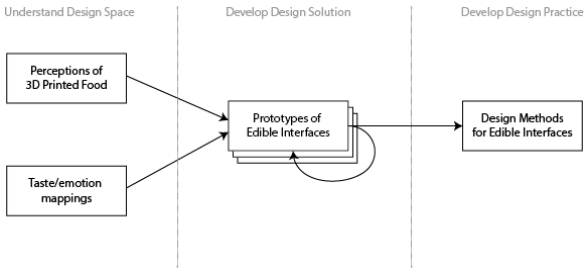

Figure **1 Proposed Research Plan**

6 RESEARCH TIMELINE

The first period of my study has been concerned with understanding 3D printed food and affective experience through food, these two areas of knowledge are key to aiding the development of my initial Edible Interface prototypes (see Figure 1). Following the completion of the two studies mentioned I will conduct the first research with a prototype design. This will initiate an iterative cycle of research that will continue through my PhD. These activities will be supported by a progressive gathering of approaches to edible and multisensory interfaces and though adding my own findings I will construct bespoke methods for further work.

7 CONCLUSION

7.1 Future Directions

My current research is building a foundation of knowledge for the creation of prototype 'Edible Interfaces'. Following the work on Thermal UIs by Wilson et al. [33] I have devised scenario designs that are considerate of the particular qualities of food as an interactive medium; both in the interaction method, as well as in their informational content. The scenarios I have chosen reflect a range of both input and output activities, in both digital and non-digital contexts. Preliminary results have informed a focus on affective information content, exploiting the emotional mappings of bitterness and sweetness. Following Wilson et al. [33] I also am developing experimental procedure in which participants are not predisposed to interpretations of interfaces mappings. The aim of this is to reflect a much more natural use case in which prior knowledge of an interface cannot be taken for granted.

7.2 Contributions

My contributions so far have centered around understanding perceptions of 3D printed food and the relevance of taste-emotion mappings to applied contexts. 3D printed food is a technology that has thus far largely been explored outside of the context of HCI and my work contributes both to its wider uses as well as to its understanding as a design tool for use in HCI. Research into applied mappings adds to the discussion and exploration of affective computing, especially from a multisensory perspective.

My upcoming research is focused on developing knowledge on the design of Edible Interfaces. The intention is to deliver interface designs and concepts that are documented to support future implementation by other researchers and designers, both within this field and beyond. Through my iterative approach, I also hope to contribute to the design methods used in multisensory HCI and to provide insights into understanding experience that have a wider relevance as well.

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REFERENCES

[1] Alissa N. Antle, Greg Corness, and Milena Droumeva. 2009. What the body knows: Exploring the benefits of embodied metaphors in hybrid physical digital environments. *Interacting with Computers* 21, 1–2: 66–75.

[2] Angela Bearth and Michael Siegrist. 2016. Are risk or benefit perceptions more important for public acceptance of innovative food technologies: A meta-analysis. *Trends in Food Science & Technology* 49: 14–23.

[3] Wender L. P. Bredie, Hui Shan Grace Tan, and Karin Wendin. 2014. A Comparative Study on Facially Expressed Emotions in Response to Basic Tastes. *Chemosensory Perception* 7, 1: 1–9.

[4] Jaz Hee-jeong Choi, Marcus Foth, and Greg Hearn. 2014. Eat, cook, grow [electronic resource]: mixing human-computer interactions with human-food interactions. .

[5] Rob Comber, Jaz Hee-jeong Choi, Jettie Hoonhout, and Kenton O'Hara. 2014. Designing for human–food interaction: An introduction to the special issue on "food and interaction design." *International Journal of Human-Computer Studies* 72, 2: 181–184.

[6] Carole M. Counihan. 2012. VI.14 The Social and Cultural Uses of Food. In K.F. Kiple and K.C. Ornelas, eds., *The Cambridge World History of Food*. Cambridge University Press, Cambridge.

[7] D. N. Cox and G. Evans. 2008. Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. *Food Quality and Preference* 19, 8: 704–710.

[8] Dovetailed Ltd. nūfood Printer. *nūfood*. Retrieved March 8, 2017 from http://www.nufood.io.

[9] Sally Eden, Christopher Bear, and Gordon Walker. 2008. Understanding and (dis)trusting food assurance schemes: Consumer confidence and the "knowledge fix." *Journal of Rural Studies* 24, 1: 1–14.

[10] Paul Ekman. 1992. An Argument for basic emotions. *Cognition and Emotion* 6, 3/4: 169–200.

[11] G. Evans, C. Kermarrec, T. Sable, and D. N. Cox. 2010. Reliability and predictive validity of the Food Technology Neophobia Scale. *Appetite* 54, 2: 390–393.

[12] James Jerome Gibson. 1986. *The ecological approach to visual perception*. Lawrence Erlbaum Associates, Hillsdale, NJ.

[13] Fernanda C. Godoi, Sangeeta Prakash, and Bhesh R. Bhandari. 2016. 3d printing technologies applied for food design: Status and prospects. *Journal of Food Engineering* 179: 44–54.

[14] Andrea Grimes and Richard Harper. 2008. Celebratory Technology: New Directions for Food Research in HCI. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 467–476.

[15] Kasun Karunanayaka, Adrian David Cheok, Nur Amira Samshir, et al. 2016. Electric, thermal, and magnetic based digital interfaces for next generation food experiences. *Integrative Food, Nutrition and Metabolism* 3, 1: 243–250.

[16] Moran Mizrahi, Amos Golan, Ariel Bezaleli Mizrahi, Rotem Gruber, Alexander Zoonder Lachnise, and Amit Zoran. 2016. Digital Gastronomy: Methods & Recipes for Hybrid Cooking. *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*, ACM, 541–552.

[17] S. Mustonen, I. Hissa, A. Huotilainen, S.-M. Miettinen, and H. Tuorila. 2007. Hedonic responses as predictors of food choice: Flexibility and self-prediction. *Appetite* 49, 1: 159–168.

[18] Marianna Obrist, Rob Comber, Sriram Subramanian, Betina Piqueras-Fiszman, Carlos Velasco, and Charles Spence. 2014. Temporal, Affective, and Embodied Characteristics of Taste Experiences: A Framework for Design. *Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems*, ACM, 2853–2862.

[19] Marianna Obrist, Carlos Velasco, Chi Thanh Vi, et al. 2016. Touch, Taste, & Smell User Interfaces: The Future of Multisensory HCI. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, ACM, 3285–3292.

[20] Kenton O'Hara, John Helmes, Abigail Sellen, Richard Harper, Martijn ten Bhömer, and Elise van den Hoven. 2012. Food for talk: Phototalk in the context of sharing a meal. *Human–Computer Interaction* 27, 1–2: 124–150.

[21] Marleen C. Onwezen and Jos Bartels. 2013. Development and cross-cultural validation of a shortened social representations scale of new foods. *Food Quality and Preference* 28, 1: 226–234.

[22] Paul. Dourish. 2001. *Where the action is: the foundations of embodied interaction*. MIT Press, Cambridge, Mass.

[23] Nimesha Ranasinghe, Gajan Suthokumar, Kuan Yi Lee, and Ellen Yi-Luen Do. 2014. Digital Flavor Interface. *Proceedings of the Adjunct Publication of the 27th Annual ACM Symposium on User Interface Software and Technology*, ACM, 47–48.

[24] Erica Robles and Mikael Wiberg. 2010. Texturing the material turn in interaction design. *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction*, ACM, 137–144.

[25] Everett M. Rogers. 2003. *Diffusion of Innovations, 5th Edition*. Free Press, New York.

[26] Paul Rozin. 2012. VI.11 The Psychology of food. In K.F. Kiple and K.C. Ornelas, eds., *The Cambridge World History of Food*. Cambridge University Press, Cambridge.

[27] James A. Russell. 2003. Core affect and the psychological construction of emotion. *Psychological Review* 110, 1: 145–172.

[28] Charles Spence. 2003. Crossmodal Attention and Multisensory Integration: Implications for Multimodal Interface Design. *Proceedings of the 5th International Conference on Multimodal Interfaces*, ACM, 3–3.

[29] Charles Spence. 2017. *Gastrophysics: The New Science of Eating*. Penguin UK.

[30] Yngve Sundblad, Michel Beaudouin-Lafon, Stéphane Conversy, et al. 2003. Technology probes: inspiring design for and with families. *Proceedings of the SIGCHI conference on Human factors in computing systems*: 17–24.

[31] Marc Tuters and Denisa Kera. 2014. Hungry for Data: Metabolic Interaction from Farm to Fork to Phenotype. In J.H.-J. Choi, M. Foth, and G. Hearn, eds., *Eat, Cook, Grow: Mixing Human-Computer Interactions with Human-Food Interactions*. The MIT Press, Cambridge, Mass., 243–264.

[32] Anna Vallgårda and Johan Redström. 2007. Computational Composites. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 513–522.

[33] Graham Wilson, Gavin Davidson, and Stephen A. Brewster. 2015. In the Heat of the Moment: Subjective Interpretations of Thermal Feedback During Interaction. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, ACM, 2063–2072.

[34] Fan Yang, Min Zhang, and Bhesh Bhandari. 2017. Recent development in 3D food printing. *Critical Reviews in Food Science and Nutrition* 57, 14: 3145–3153.