The Singing Carrot: Designing Playful Experiences with Food Sounds

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Abstract
Food sounds – sounds that certain foods make during eating through chewing, biting or licking – are key parts of the eating experience. They play an important role in establishing our perception about the palatability of food. We believe interactive technology offers unique opportunities to create novel playful experiences with food by playing with these sounds. In exploring this opportunity, we outline a structure on how we can explore playful sounds and present one case study of a novel interactive food experience: "The singing carrot". The singing carrot generates unique digital sounds while eating a carrot. Ultimately, with our work, we aim to inspire and guide designers working with interactive playful food sound.

CSS concepts
• **Human-centered computing → Ubiquitous and mobile computing design and evaluation methods** • *Human-centered computing → Interaction design*

Author Keywords
Food sounds; Food Play; Human-Food interaction;

(a) No sounds before eating

(b) Generating sounds during eating

(c) Finishing biting a portion of the carrot

Figure 1: Images (a)- (c) The sound of The Singing Carrot that the user is generating through eating the carrot.

Introduction

Food not only satisfies our hunger, its consumption is also a rich multi-sensory experience, where vision, smell, touch, taste and sound play a unique role in the perception of food, making the experience worthwhile [23,25,26,28]. In this paper, we are interested in sound; especially food sounds that is the sound that certain foods make during eating.

The effects of sound on the eating and drinking experience are usually overlooked: most people seem to believe that sound is the least important sense when it comes to experiencing food and drinks [31]. Contrary to this belief, research has demonstrated that sound plays a far more important role, since our perception of taste is highly affected by sound. For instance, we perceive freshness of potato chips by the quality of its crisp sound that it makes during eating [32]. We also see a growing popularity of Autonomous Sensory Meridian Response (ASMR) [4] videos where sounds, including food sounds, are used to offer a sensual hedonic appeal.

Ambient sounds and music also influence our experience of a meal. Restaurants have started to use sound as a new ingredient. For instance, the dish "Sound of the Sea" served in The Fat Duck [34] is a seashell with an MP3 player with a pair of ear buds. The diner is encouraged to listen to the sound of the sea before eating, suggesting that music could enhance our eating experience. Meanwhile, Milliman et al. [22] found that playing faster background music can increase people's rate of eating in a restaurant. Roballey et al. [29] conducted that the diners take more bites when fast music was played in a cafeteria.

If we look at existing literature, we see only limited knowledge on how to use sound for play during eating. Most of the works in the field of HFI (Human Food Interaction) seem to focus on building corrective technology [10] around food to address eating problems and on using sensory cues to support healthy behaviors [7,8,14,24]. For example, Kadomura et al. [15] designed "EducaTableware" that includes two digital cutlery pieces, a fork and a cup that emit sounds during eating and drinking. The system has been used to teach children better eating habits through sound. Although corrective technologies are designed for an optimal healthy eating experience, they often do not blend well with intuitive eating [5], that is "making food choices without experiencing guilt or an ethical dilemma, honouring hunger, respecting fullness and enjoying the pleasure of eating" [10]. A corrective goal of building technologies around eating for the sole sake of health could thus fall short in engaging people with a pleasurable experience and we need an additional perspective on how to build technologies around food. Following Grimes et al. [10], we argue for designing celebratory technology that harnesses positive aspects of human-food interaction, which includes creativity, pleasure, and relaxation to support enjoyable and memorable eating experiences. This stance informs our aim to explore playful forms of eating through playing with food sounds.

In this paper, we outline a structure of how we can explore food sounds playfully. We also present a case study where we use the act of eating food to generate new digital sounds. We present "The singing carrot" (Fig 1), which detects our food consumption using capacitive touch sensing. The carrot generates unique digital sounds while being eaten. These digital sounds can promote a playful side on sonification. We believe using food sound that is generated by the act of eating can offer an enjoyable way of engaging with food. Our work is relevant to CHI PLAY as it supports cross-modal gameplay around the everyday practice of eating while encouraging a playful attitude towards food [21].

Related Work

Although sound has been described as the forgotten sense of the eating and drinking experience [33], research on sound related experiences of eating and drinking has grown rapidly in recent years [6,35,36].

Perception of food sounds

Eating related sounds play a critical role in eating and drinking experiences as they can affect our perception and enjoyment of food attributes such as crispness and freshness. Zampini and Spencer [37] conducted a famous experiment called "sonic chips ". The results demonstrated that simply by changing the frequency of chips' sound during biting action, people's perception of crispness and freshness of the chips could be modified. Similarly, Knoeferle et al. [18] investigated how different attributes of a sound can influence our perception of flavor during eating and drinking. These works show that the sounds during eating have great potential to support pleasant food experiences.

Sounds linked with eating

In the field of HFI researchers have used our masticating sounds while chewing or slurping to enhance our eating experience. Koizumi et al. [19] developed "Chewing Jockey", a playful headset that detects a user's jaw movement and plays back the pre-recorded food sounds while the user eats. This work suggested that playing back sounds of creatures screaming could provide users with a playful eating experience when they are chewing gummy sweets in the shape of fantasy creatures. Hashimoto et al. [11] proposed a virtual drinking system called "Straw-like User interface" that represented the sucking sound and vibration sensation associated with sucking a beverage with a straw. Arnold et al. [1] developed a virtual reality (VR) game that uses the chewing sound as a game input to enrich the VR experience. These works have contributed to knowledge on how to improve the game experience using food, however, how to enrich food through sound is relatively underexplored.

Food sound sonification

Sonification [13] is utilizing non-verbal sound to present information so that users are getting a better understanding of the data. Recently, model-based sonification [12] has explored *how to create an instrument from data*, so that the user interacts with a sonification item with its natural sonic features. For example, Barrass designed a medical diagnostic singing bowl that was informed by mapping a year of blood pressure data to encourage a healthy lifestyle through sonification [3]. We find that sonification techniques can be an interesting approach to motivate people to do physical activity. For example, Newbold et al. [27] used music to represent the users' real-time squat movement. The system motivates people who struggle with the movement by associating pleasant experiences with squat exercises. Similarly, Khot et al. [16,17] explored using sports drink fountains and 3D printed chocolate to motivate users to do physical activity. The authors found that the participants not only enjoyed edible and drinkable data but also engaged with the sound of the sports drinks and the 3D printing sound. Inspired by the above works, our research aims to

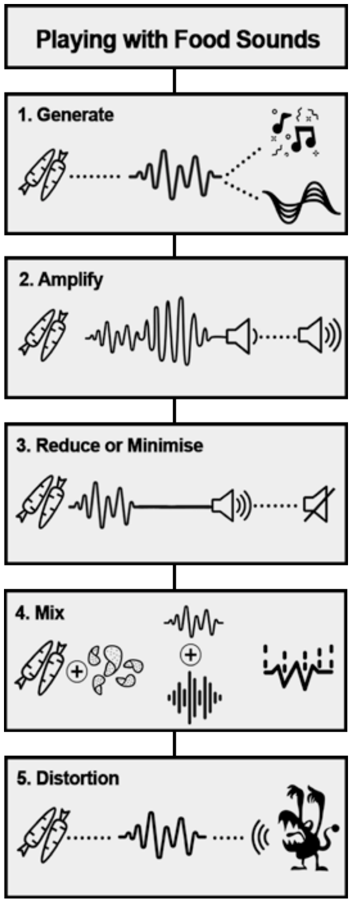

Figure 2: Playing with food sounds structure, consisting of 5 categories.

extend the possibilities of food sound sonification to create playful sound experiences associated with food consumption. As a result, we propose the following research question: "How do we design playful food experiences with sound?" To answer this question, we outline a structure and put forward a case study of a novel interactive experience called "the singing carrot", which we explain below.

Designing playful experiences with food sounds

To understand how to design playful experiences with food sounds, we conducted a focus group discussion to generate and refine ideas and to offer a structure to our thoughts. Seven participants (5 male, 2 female) that include 2 sound designers, 2 interactions designers, 1 electrical engineer and 2 game designers participated in the discussion that lasted for 2 hours.

The focus of the discussion was to articulate and understand possible means of supporting play through food sounds. The varied expertise of the participants allowed us to discuss not only the options of possible manipulations of digital sound but also its feasibility using current sensing technologies. Besides the focus group discussion, existing literature on gastrophysics [31] was also instrumental in enabling a better understanding of how sounds could lead to playful experience during eating. We also drew on Lucero et al.'s playful experience (PLEX) framework [20] to describe a checklist of possible playful user experiences with food sounds. This exploration has resulted in an initial structure (as described in fig.2) of how to play with food sounds, which includes the following five key categories.

1) Generate: The first possibility of playing with sound is to use food sounds to generate new digital sounds, distinct from the original food sounds.
For example, when users eat a given food, for example potato chips, they will hear a different digital sound than the traditional crispy sound. In order to do this, we can utilize digital oscillators to generate new sounds by controlling the frequency of the oscillators. Users can also utilize and control pre-recorded sounds or musical notes. This experience does not have to be limited to individuals, for example in a social dining setting we can imagine a musical symphony, where each diner is contributing a new sound through his/her eating behavior.

2) Amplify: The second possibility is to amplify the existing food sounds where the act of eating food can serve as a volume slider. The amplification of sounds could offer a better understanding of one's eating behavior and it could also be an interface to external tasks. For example, the amplified food sounds could serve as feedback mechanism, specifically in VR games where eating is used as a game interface [1].

3) Reduce: The third possibility is instead of amplifying, we can potentially cancel or reduce the intensity of existing food sounds. The reduction is particularly useful in theatrical play on meditation games, where players need to focus their attention on other senses, as the sense of sound is absent. We envision using white/pink noise to reduce or minimize eating noise for users. Reducing sound could be beneficial for users with auditory disorder [30].

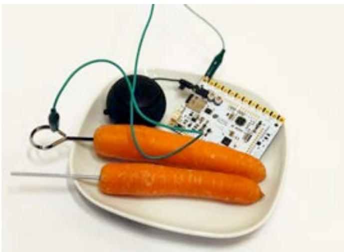

Figure 3: The Singing Carrot setup

4) Mix: The fourth possibility is blending two different food sounds to facilitate novel sound experiences. Participants will hear a mix of crispness and crunchiness food sounds during eating. For instance, eating bananas may sound like eating carrots and vice versa. The possible game mechanics could be to identify the right food through other means such as eating speed and biting force.

5) Distort: The final possibility is to distort food sounds. Players can create a unique eating experience by exploring various sound effects. For example, distorting existing sounds in order to make it sound like the screaming sounds of the fantasy creatures. Think of participants begin to lick ice cream, they will hear the screaming sounds of the fantasy creatures through licking the ice cream each time.

We also note that this is not an exhaustive list and further explorations might lead to more categories. We next describe our first case study, which looks at the first possibility of generating new sounds.

The Singing Carrot

The Singing Carrot is an exploration of food sound that dynamically generates new digital sound when the user eats a carrot. It generates digital sounds by using the measured capacitance of the food when the user is eating it. With The Singing Carrot we also focus on playing with food sound to celebrate the experience of eating. Since different users have different eating actions, the generated sound is personalized.

We started working with carrots as it has a distinctive food sound. We detect food consumption using capacitive sensing across the following stages: before the carrot is eaten, while the carrot touches the user's lips or tongue, and while the carrot is outside the user's mouth again. Each stage results in greatly different capacitance values. We use a skewer to connect the carrot with the circuit board. Before the carrot is eaten, the capacitance values are used for triggering our system. Then the user is free to perform any sort of eating action, for instance, biting or licking, which results in a variation of food capacitance values. The sensed food capacitance value is then mapped to the frequency of a sinewave. As the value of food capacitance is being changed by the action of eating, each user generates different kinds of sounds. The process stops after the carrot is eaten.

Implementation

Our prototype consists of three parts (fig.3), a "Bareconductive touch board" [2], a metallic skewer that is connected to the board, and a raw carrot. The board senses capacitance data while the user eats food. As an initial exploration, we set up a sound level at 80 dB [37]. We chose the fundamental sinewave sound because this seems to be the standard digital sound. In Processing [9], we set a basic frequency that ranges in between 300Hz to 4000Hz.

Future work

In future work, we will create a smaller device and develop more playful sounds. We will complete our proposed system to include all five categories from the initial structure. We are then planning to do a study to understand the experience of engaging with the system. We will recruit 20 participants to interact with our system while eating carrots. At the end of the study, semi-structured interviews will be conducted with the participants to reflect upon their experience. Results of the analysis will guide us towards understanding how to design playful food sound experiences.

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References

1. Peter Arnold. 2017. You Better Eat to Survive! Exploring Edible Interactions in a Virtual Reality Game. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA ’17), 206–209. https://doi.org/10.1145/3027063.3048408
2. Bare Conductive. Ready to integrate into your interactive projects - Bare Conductive. Retrieved July 9, 2018 from https://www.bareconductive.com/
3. Stephen Barrass. 2016. Diagnosing blood pressure with Acoustic Sonification singing bowls. *International Journal of Human Computer Studies* 85: 68–71. https://doi.org/10.1016/j.ijhcs.2015.08.007
4. Emma L. Barratt and Nick J. Davis. 2015. Autonomous Sensory Meridian Response (ASMR): a flow-like mental state. *PeerJ* 3: e851. https://doi.org/10.7717/peerj.851
5. Leslie Cadena-Schlam and Gemma López-Guimerà. 2015. Intuitive eating: An emerging approach to eating behavior. *Nutrición Hospitalaria* 31, 3: 995–1002. https://doi.org/10.3305/nh.2015.31.3.7980
6. Felipe Reinoso Carvalho, Kris Steenhaut, Raymond van Ee, Abdellah Touhafi, and Carlos Velasco. 2016. Sound-enhanced gustatory experiences and technology. In *Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction - MHFI ’16*, 1–8. https://doi.org/10.1145/3007577.3007580
7. Pei-Yu Peggy Chi, Hao-Hua Chu, Jen-hao Chen, and Bing-Yu Chen. 2007. Enabling nutrition-aware cooking in a smart kitchen. *Persuasive 2008, Lncs 5033*: 116–127. https://doi.org/http://doi.acm.org/10.1145/1240866.1241003
8. 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*, 181–184. https://doi.org/10.1016/j.ijhcs.2013.09.001
9. Processing Foundation. Processing Foundation. Retrieved July 9, 2018 from https://processing.org/
10. Andrea Grimes and Richard Harper. 2008. Celebratory Technology : New Directions for Food Research in HCI. *Chi 2008*: 467–476. https://doi.org/10.1145/1357054.1357130
11. Yuki Hashimoto, Naohisa Nagaya, Minoru Kojima, Satoru Miyajima, Junichiro Ohtaki, Akio Yamamoto, Tomoyasu Mitani, and Masahiko Inami. 2006. Straw-like User Interface : Virtual experience of the sensation of drinking using a straw. *Association for computing Machinery* 6: 14–16. https://doi.org/10.1145/1178823.1178873
12. Thomas Hermann. 2010. Sonic interaction design: new applications and challenges for interactive sonification. *Proc. Digital Audio Effects (DAFx-10)*: 1–34.
13. Thomas Hermann, John Williamson, Roderick Murray-Smith, Yon Visell, and Eoin Brazil. 2008. Sonification for Sonic Interaction Design. In *Proc. of the CHI 2008 Workshop on Sonic Interaction Design (SID)*, 35–40. https://doi.org/10.1037/0096-3445.115.1.39
14. Azusa Kadomura, Cheng-Yuan Li, Koji Tsukada, Hao-Hua Chu, and Itiro Siio. 2014. Persuasive technology to improve eating behavior using a sensor-embedded fork. *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*: 319–329. https://doi.org/10.1145/2632048.2632093
15. Azusa Kadomura, Koji Tsukada, and Itiro Siio. 2014. EducaTableware: Sound Emitting Tableware for

Encouraging Dietary Education. *Journal of Information Processing* 22, 2: 325–333. https://doi.org/10.2197/ipsjjip.22.325

16. Rohit Ashok Khot, Deepti Aggarwal, Ryan Pennings, Larissa Hjorth, and Florian Floyd Mueller. 2017. EdiPulse: Investigating a Playful Approach to Self-monitoring through 3D Printed Chocolate Treats. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*: 6593–6607. https://doi.org/10.1145/3025453.3025980
17. Rohit Ashok Khot, Jeewon Lee, Deepti Aggarwal, Larissa Hjorth, and Florian "Floyd" Mueller. 2015. TastyBeats: Designing Palatable Representations of Physical Activity. *Proceedings of the ACM CHI'15 Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/2702123.2702197
18. Klemens M. Knoeferle, Andy Woods, Florian Käppler, and Charles Spence. 2015. That Sounds Sweet: Using Cross-Modal Correspondences to Communicate Gustatory Attributes. *Psychology and Marketing* 32, 1: 107–120. https://doi.org/10.1002/mar.20766
19. Naoya Koizumi, Hidekazu Tanaka, Yuji Uema, and Masahiko Inami. 2011. Chewing jockey. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE '11*, 1. https://doi.org/10.1145/2071423.2071449
20. Andrés Lucero, Jussi Holopainen, Elina Ollila, Riku Suomela, and Evangelos Karapanos. 2013. The playful experiences (PLEX) framework as a guide for expert evaluation. In *Proceedings of the 6th International Conference on Designing Pleasurable Products and Interfaces - DPPI '13*, 221. https://doi.org/10.1145/2513506.2513530
21. Andrés Lucero, Evangelos Karapanos, Juha Arrasvuori, and Hannu Korhonen. 2014. Playful or Gameful? *interactions* 21, 3: 34–39. https://doi.org/10.1145/2590973
22. R E Milliman. 1986. The influence of background music on the behaviour of restaurant patrons. *Journal of Consumer Research* 13, 2: 286–289.
23. Martin Murer, Ilhan Aslan, and Manfred Tscheligi. 2013. LOLL io. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction - TEI '13*, 299. https://doi.org/10.1145/2460625.2460675
24. Javaid Nabi, Abhijit Rajashekar Doddamadaiah, and Raghav Lakhotia. 2016. Smart Dietary Monitoring System. In *Proceedings - 2015 IEEE International Symposium on Nanoelectronic and Information Systems, iNIS 2015*, 207–212. https://doi.org/10.1109/iNIS.2015.20
25. Takuji Narumi, Yuki Ban, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. 2012. Augmented Perception of Satiety: Controlling Food Consumption by Changing Apparent Size of Food with Augmented Reality. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*: 109–118. https://doi.org/10.1145/2207676.2207693
26. Takuji Narumi, Shinya Nishizaka, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. 2011. Meta cookie+: An illusion-based gustatory display. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 260–269. https://doi.org/10.1007/978-3-642-22021-0_29
27. Joseph W. Newbold, Nadia Bianchi-Berthouze, and Nicolas E. Gold. 2017. Musical Expectancy in Squat Sonification for People Who Struggle with Physical Activity. *ICADThe 23rd International Conference on Auditory Display*: 65–72. https://doi.org/10.21785/icad2017.008
28. John Prescott. 2015. Multisensory processes in flavour perception and their influence on food choice. *Current Opinion in Food Science 3*, 47–52. https://doi.org/10.1016/j.cofs.2015.02.007
29. Thompson Roballey, Colleen McGreevy, Richard R. Rongo, Michelle L. Schwantes, Peter J. Steger, Marie A. Wininger, and Elizabeth B. Gardner. 1985. The effect of music on eating behavior. *Bulletin of the Psychonomic Society* 23, 3: 221–222.
30. Romke Rouw and Mercede Erfanian. 2018. A Large-Scale Study of Misophonia. *Journal of Clinical Psychology* 74, 3: 453–479.

https://doi.org/10.1002/jclp.22500

31. C Spence. 2017. *Gastrophysics: The New Science of Eating*. Penguin Publishing Group.
32. Charles Spence. 2015. Eating with our ears: assessing the importance of the sounds of consumption on our perception and enjoyment of multisensory flavour experiences. *Flavour* 4, 1: 3. https://doi.org/10.1186/2044-7248-4-3
33. Charles Spence. 2016. Sound: The Forgotten Flavor Sense. In *Multisensory Flavor Perception: From Fundamental Neuroscience Through to the Marketplace*. 81–105. https://doi.org/10.1016/B978-0-08-100350-3.00005-5
34. The Fat Duck. 2018. The Fat Duck. Retrieved April 12, 2018 from http://www.thefatduck.co.uk/
35. Carlos Velasco, Felipe Reinoso Carvalho, Olivia Petit, and Anton Nijholt. 2016. A Multisensory Approach for the Design of Food and Drink Enhancing Sonic Systems. *Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction MHFI '16*: 1–7. https://doi.org/10.1145/3007577.3007578
36. Qian J. Wang, Klemens Knoeferle, and Charles Spence. 2017. Music to make your mouth water? Assessing the potential influence of sour music on salivation. *Frontiers in Psychology* 8, APR. https://doi.org/10.3389/fpsyg.2017.00638
37. Massimiliano Zampini and Charles Spence. 2004. The role of auditory cues in modulating the perceived crispness and staleness of potato chips. *Journal of Sensory Studies* 19, 5: 347–363. https://doi.org/10.1111/j.1745-459x.2004.080403.x