Understanding the Design of Playful Gustosonic experiences

Yan Wang

Master of Software Engineering,

Peking University, China

A Thesis Submitted for the Degree of Doctor of Philosophy at

Monash Universityin 2021

School of Information Technology

Copyright notice

Abstract

Sound plays an important role in eating and drinking experiences, as highlighted through the term "gustosonic experiences". "Gustosonic" refers to multisensory interactions between sound and the act of eating/drinking. With the advancement of interactive technology, there is growing research on the topic of multisensory interactions in human-computer interaction (HCI). However, the use of interactive technology to support gustosonic experiences has been mostly underexplored in HCI. To contribute to this exploration, this research aims to understand the design of playful gustosonic experiences; this has resulted in three playful gustosonic systems. Firstly, an augmented ice cream cone called "iScream!" allows players to generate four playful sounds through eating ice cream. Secondly, "WeScream!" allows two players to compose rhythmical sounds through eating ice cream together. Thirdly, "Sonic Straws" allows players to experience personalised sounds via drinking beverages through straws. Qualitative studies have examined the experiences of using these gustosonic systems, resulting in a novel design framework that articulates four key qualities of playful gustosonic experiences (exploration of eating sounds at the initial moment, self-expression via eating actions in the moment, relatedness of eating together at a shared moment and reflection on everyday eating activities beyond the moment). Taken together, this work advances interaction design theory by introducing the concept of playful gustosonic experiences, contributing to the enrichment of eating and drinking experiences through playful design and ultimately furthering how we eat in the future.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:

Print Name: Yan Wang

Date: 20 August 2021

Publications During Enrollment

Major portions of this thesis have been peer-reviewed, published and presented to wider HCI audiences. My paper reporting the study on WeScream! won the Best Paper Honorable Mention Award at DIS 2020. My iScream! work has resulted in several papers at academic venues including CHI PLAY 2018 and CHI 2019 during my candidature. The complete list of publications is presented below.

Peer-reviewed publications

Full papers

• **Wang, Y**., Li, Z., Jarvis, R. S., Russo, A., Khot, R. A., and Mueller, F. (2019b). Towards understanding the design of playful gustosonic experiences with ice cream. In *Proceedings of the 2019 Annual Symposium on Computer-Human Interaction in Play*, pages 239–251.

• **Wang, Y.**, Li, Z., Jarvis, R. S., La Delfa, J., Khot, R. A., and Mueller, F. F. (2020c). WeScream! toward understanding the design of playful social gustosonic experiences with ice cream. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pages 951–963. **Best Paper Honorable Mention**

• **Wang, Y**., Li, Z., Khot, R. A., and Mueller, F. (2021). Toward understanding playful beverage-based gustosonic experiences. (under review)

Short papers

• **Wang, Y**., Li, Z., Jarvis, R., Khot, R. A., and Mueller, F. F. (2018). The singing carrot: Designing playful experiences with food sounds. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, pages 669–676.

• **Wang, Y**., Li, Z., Jarvis, R., Khot, R. A., and Mueller, F. (2019a). iScream! towards the design of playful gustosonic experiences with ice cream. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–4.

• **Wang, Y**., Zhang, X., Li, Z., Khot, R. A., and Mueller, F. (2020a). Towards a framework for designing playful gustosonic experiences. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–9.

- **Wang, Y**. (2020b). Understanding the design of playful gustosonic experiences. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–8.

- **Wang, Y**., Zhang, X., Li, Z., Khot, R. A., and Mueller, F. (2021a). Sonic Straws: A beverage-based playful gustosonic system. In *Adjunct Proceedings of the 2021 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2021 ACM International Symposium on Wearable Computers*, 2 pages.

Collaborative works on playful eating experiences that contributed to furthering my work

- Deng, J., **Wang, Y**., Velasco, C., Altarriba Altarriba Bertran, F., Comber, R., Obrist, M., Isbister, K., Spence, C., and Mueller, F. (2021). The future of human-food interaction. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–6.

- Khot, R. A., Arza, E. S., Kurra, H., and **Wang, Y**. (2019). Fobo: Towards designing a robotic companion for solo dining. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–6.

- Mueller, F., Kari, T., Khot, R., Li, Z., **Wang, Y**., Mehta, Y., and Arnold, P. (2018). Towards Experiencing Eating as a Form of Play. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, pages 559–567.

- Mueller, F., **Wang, Y**., Li, Z., Kari, T., Arnold, P., Mehta, Y. D., Marquez, J., and Khot, R. A. (2020). Towards experiencing eating as play. In *Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 239–253.

- Mueller, F., Dwyer, T., Goodwin, S., Marriott, K., Deng, J., D. Phan, H., Lin, J., Chen, K.-T., **Wang, Y**., and Ashok Khot, R. (2021). Data as delight: Eating data. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–14.

Acknowledgements

I would like to thank many people for providing invaluable help to my PhD journey during the past years.

First and foremost, I would like to express my sincere gratitude to my supervisors, Prof. Florian 'Floyd' Mueller and Dr Rohit Ashok Khot, for their continued support, insightful guidance and advice, patience and consistent encouragement in this great adventure.

I would like to thank all my panel members at my PhD milestones, Prof. Patrick Oliver, Dr Kirsten Ellis, A/Prof. Joanne Evans, A/Prof. Benny Jenny, A/Prof. Lawrence Harvey and Dr Lisa Dethridge, for their great insights, comments and feedback.

I am deeply thankful to all members of the Exertion Games Lab: Zhuying, Nathan, Rekaesh, Jialin, Joseph, Betty, Justin and Jonathan. Thanks for the feedback and tremendous help during the past years. I also thank the friends I made in Melbourne: Deepti, Ellie, Lois, Nandini and Jason, thank you all for making my PhD life in Melbourne enjoyable and memorable. I will miss all the times when we were having lunch and chatting together. I wish all of you the best in everything you do.

I am grateful to everyone who helped with my work. Deep thanks to Bob and Joe for helping with the sound system design and my lovely ice cream cone. Thanks to Mengting for helping with cup concept design. Thanks to all my participants, who were willing to take part in my study, enjoyed the ice cream in winter and provided so much interesting feedback. Thanks to Rina, Karl and Alex for helping with the excellent videos.

I am thankful to the Faulty of Information Technology, Monash University for supporting my research with a Faculty of Information International Postgraduate Research Scholarship.

Accredited professional editor Mary-Jo O'Rourke AE provided copyediting and proofreading services according to the national university-endorsed 'Guidelines for editing research thesis' (Institute of Professional Editors, 2019).

I am grateful to all my friends in my life: Shinko Zhang, Juyi Jia, Haizhen Li, Yuan Wang and many more. Thank you for being part of my life and cheering me up when I encountered difficulties during this adventure. My special thanks to Sukki Yao. Thanks for the company during my PhD journey. Through all the late nights and my ups and downs, you made me laugh and encouraged me to keep going. I will remember every moment I have had with you.

Lastly, I am deeply thankful to my loving mother, Boru Gao, for her ever lasting support and confidence in me and unconditional love throughout my life. Thank you for giving

me the strength to keep going on this PhD adventure and always having my back. Thank you for giving me the confidence to pursue my dreams. You will never know how deeply grateful I am for everything you have done for me. Thank you so much for letting me be myself. I will love you forever.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

THIS thesis explores the design of playful gustosonic experiences. In this chapter, I briefly introduce the research motivation and articulate the contributions.

1.1 Human-food interaction

Human-food interaction (HFI) has emerged as an area of interest within the human-computer interaction (HCI) community where researchers explore the role of technology in supporting food-related practices (Choi et al., 2014; Khot et al., 2019b; Obrist et al., 2018). For example, research has produced robotic systems to support efficient harvesting practices (Hayashi et al., 2002; Van Henten et al., 2003), smart kitchens have been developed to support food preparation and cooking processes (Blasco et al., 2014; Hashimoto et al., 2008), and self-tracking technologies have been used to track food nutrition for health eating (Graham and Jeffery, 2012; Hanson-Smith et al., 2006; Huang et al., 2017). Taken together, interactive technology around food-related practices is gradually shaping our ways of engaging with food.

Eating and drinking can afford rich multisensory experiences in our everyday lives (Spence, 2017b). Given the ubiquitous nature of technology and advances in sensing technology, researchers and HCI practitioners have recently begun investigating the use of technology to influence our multisensory interactions with food in order to enrich eating and drinking experiences (Obrist et al., 2017; Velasco et al., 2018). For example, a pseudo-gustatory simulation system allows the user to taste various food flavours by interactively projecting changing LED colours onto beverages (Narumi et al., 2010). Another example is an augmented reality (AR) food system that modifies the flavor of a real cookie by overlaying visual elements and digital olfactory information onto the cookie (Narumi et al., 2011b). Moreover, a galvanic tongue-stimulation technology was developed to influence taste sensations (Aoyama et al., 2017). Although these works have informed more research on multisensory interactions and the exploration of multisensory experiences, they seem to be system-centric and mainly focuses on the technical implementation to mimic human senses, for example, utilising air pumps and scented filters combined with a head-mounted interface to generate retrospective nasal olfactory stimuli to produce the scent of the cookies (Narumi et al., 2011a). On the other hand, existing works also have been designed for instrumental purposes, for example, promoting healthy eating or providing nutrition knowledge, such as sensors used in a kitchen to detect what the users were doing, then providing feedback about the nutrition value of the ingredients being used during cooking (Chi et al., 2008). However, when it comes to the design of interactive technology for food experiences, technology should affect not only how people eat and drink, but also their interactions within the eating and drinking context (Spence and Piqueras-Fiszman, 2013). Grimes and Harper (2008) underlined this by proposing that technology in food-related practices should embrace the "pleasurable aspects of eating experiences and eating as a social experience". Moreover, Khot et al. (2019b) asked for more work in the HFI field to support the experiential aspects of eating rather than a focus on technology that supports instrumental purposes for individuals, while Altarriba Bertran et al. (2019a) advocated for designing more technology-mediated eating experiences rather than engaging a techno-solutionist approach in HFI. In response to these calls, this thesis study focuses on desirable experiential qualities for interactive food systems, going beyond prior works that simply see food as calorie intake. Moreover, this study appreciates eating as cultural experiences and engages with its pleasurable characteristics, contributing to our understanding of the design of technology-meditated eating experiences through augmented multisensory interactions.

1.2 Experiencing eating as play

Most of us probably remember times when our parents told us: "Do not play with your food!" People generally do not play with food as this is considered a waste of food and a bad habit. However, playing constitutes a great part of our childhood and even adult life. Playing lies in our human nature, as it is one of the ways to explore our relationships with objects and the environment, and to express ourselves (Gillin, 1951). According to Bogost (2016), people can play with their food in high gastronomy, where the play takes place only in the mouth of the eater. This is because the material properties of food hold many sensory qualities to play with and explore, for example, its dynamically changed texture, its potentially changed state, its taste, its smell, and the sounds it makes (Spence, 2017b). Besides the fact that food affords rich sensory experiences, its cultural, social, ethical and personal aspects also make food an intriguing material for play. However, there is no clear definition of play or playfulness in the context of eating/drinking. Therefore, I propose that playful eating is an attitude similar to "paidia" (Caillois, 2001) as something not serious, where people pursue the mundane activity of eating with pleasure.

When it comes to understanding playful eating, playfulness is an attitude towards things, people and situations (Sicart, 2014; Salen et al., 2004). Gillin (1951) stated that play is an activity allowing the players to be free from the boundaries of ordinary life. The activity of playing itself is the goal. Based on Huizinga's theory, Caillois (2001) distinguished two play principles: *paidia* and *ludus*. He described paidia as a kind of uncontrolled fantasy that can be designed; in other words, play is free from rules. Similarly, Suits (1984) emphasised the importance of the "lusory attitude", which refers to the players' intrinsic motivations to engage with a playful activity (a game) when it comes to play, while being also drawn upon in relation to eating/drinking experiences; for example, people eat to avoid starvation but eating also makes people feel good (Fox, 2003). Moreover, Rozin (1999) argued for three different kinds of pleasure: sensory pleasure, aesthetic pleasure and accomplishment pleasure. I note that these kinds of pleasure can be valuable in understanding playful food experiences. For example, sensory inputs in physically localised plays critical roles in sensory pleasure, as we can experience the pleasure of food in our mouth. Aesthetic pleasures are abstract but linked to sensory inputs, while accomplishment pleasures can be derived from achieving something of value via skilful actions. Therefore, I argue that we can develop such pleasures through experiencing eating as play.

Several works in HCI have recently emerged that investigate playful interactions with food and focus on play's desirable experiential qualities in eating situations rather than focusing on pure entertainment. For example, Altarriba Bertran et al. (2019b) suggested extending playfulness to the practice of chefs and food designers to facilitate the playful aspects of eating experiences, enriching both food and associated interactions. Chisik et al. (2018) proposed "gastroludology" in eating and drinking, advocating the creation of new ways to facilitate meaningful play with food that enrich our everyday eating activities. Later, Mueller et al. (2020b) proposed intermediate-level design knowledge that suggests designing interactive technology to support eating as a form of play because food comes so close to our bodies. As such, the merging of eating and technology offers a unique opportunity to experience eating as play. Inspired by these works, this thesis study focuses on designing playful eating experiences through integrating technology into food and beverage experiences.

1.3 Gustosonic experiences

Researchers appeared to pay more attention to certain senses than others while investigating the multisensory experience in HFI; for example, there are many HFI projects focusing on the visual sense (Carvalho and Spence, 2019; Oberfeld et al., 2009; Shankar et al., 2010), the haptic sense (Biggs et al., 2016; Gemici and Saxena, 2014; Iwata et al., 2004; Tu et al., 2015) or the taste sense (Ranasinghe et al., 2011, 2017b; Zoran and Cohen, 2018). To complement these, I focus on the auditory sense, which has been described as an overlooked sense when it comes to experiencing food (Velasco et al., 2016). Research on the relationship between sound and eating has emerged in recent years, especially in the fields of experimental psychology and food science. For example, we can perceive the freshness of potato chips by the quality of the "crunch" sound and hence, if we hear crunchier sounds, chips are perceived to be fresher and more palatable (Zampini and Spence, 2004). Previous studies have also shown that background noise can influence the perception of taste; for example, the sweetness can be suppressed by loud noise (Spence et al., 2019c) while the umami taste can be enhanced with a loud background noise (Ninomiya, 2015). Moreover, emotional sonic sensation transference from music to taste can enhance the desirable taste qualities and overall multisensory food experience (Cespedes-Guevara and Eerola, 2018; Konečni, 2008; Reybrouck and Eerola, 2017). Furthermore, sound can influence our eating behaviours; for example, fast-paced background music can increase people's eating speed and facilitate taking more bites (Milliman, 1986). Building on these insights, the hospitality industry has used sound as an "extra ingredient" to facilitate rich eating experiences. For example, the dish "Sound of the Sea" (The Fat Duck, 2021) encourages diners to listen to the sound of sea waves through headphones while they eat a seafood dish. These interesting links between eating and listening within a combined multisensory experience are defined as "gustosonic experiences" (VanCour and Barnett, 2017).

Although the above works suggest that sound has great potential to contribute to enrichment of eating/drinking experiences, they focus more on measurable sound stimuli and basic taste experiences in a specific experimental setting, rather than on interactive qualities of eating experiences that might apply as people perceive those stimuli in the real world. As such, this thesis argues that there is an opportunity to explore gustosonic experiences by embracing interactive technology that affords various ways to facilitate playful interactions with food. In the next section, I propose the thesis statement and research objectives, as well as presenting an overview of how I address my research question through the exploration of three case studies.

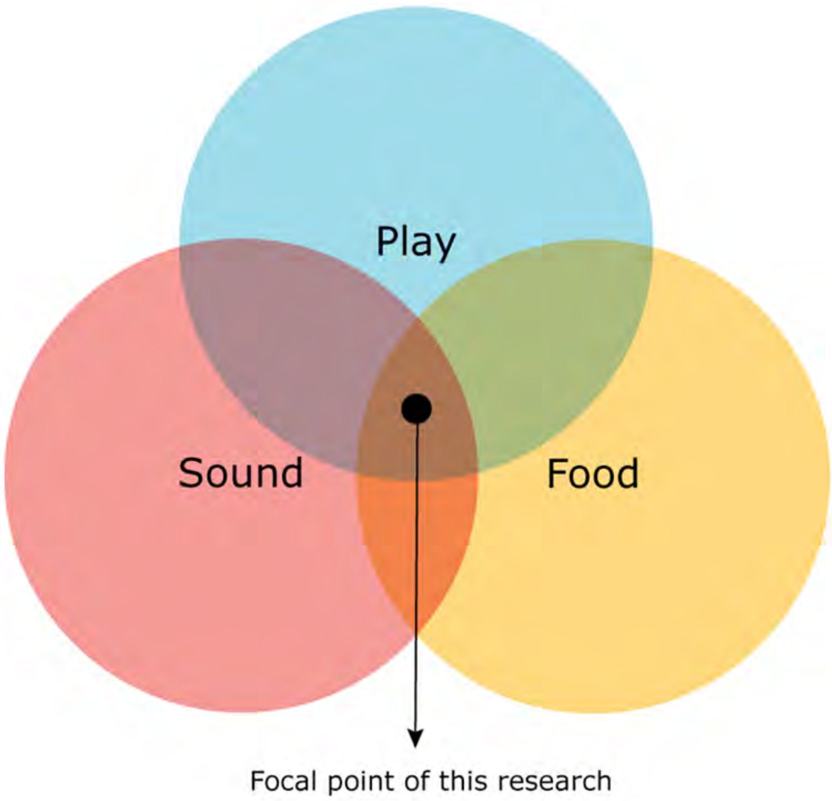

FIGURE 1.1: The focal point of the research is at the intersection of play, food and sound.

1.4 Thesis statement

This thesis investigates the design space at the intersection of food, play and sound, as shown in Figure 1.1. Therefore, I aim to answer the following research question in this thesis:

How do we design playful gustosonic experiences?

To answer this question, I have followed a research through design (RtD) approach (Zimmerman et al., 2007) by designing and studying three playful gustosonic prototypes that aim to facilitate playful eating experiences through augmented sonic interactions. These prototypes offered me opportunities to study and reflect on the associated player experiences. For each prototype, I conducted a study to investigate how the players experienced the system. Through reflecting on the design process and iterative analysis of all the findings of the three case studies, I created a design framework for designing playful gustosonic experiences to guide future designs.

Based on this empirical work the framework evolved, comprising ultimately four categories: temporality, experiential qualities of playful gustosonic experiences, exemplars related to the playful gustosonic experiences, and design features of playful gustosonic experiences. According to the definition of the temporal dimension of UX by the International Organization for Standardization (ISO 9241-210) (de Normalisation, 2010), the temporal dimension of UX is described in three phases: anticipated use, during use and after use. The temporality can help in development of UX by emphasising the different qualities of UX over time. I aligned dynamic features of the playful gustosonic experiences with four experiential qualities: exploration of eating sounds at the initial moment, self-expression via eating sounds in the moment, relatedness of eating together at the shared moment and reflections on everyday eating activities beyond the moment. Figure 1.2 presents the design framework visualised in a 5*4 diagram that can serve as a design tool for interaction designers and HCI practitioners when aiming to design future playful gustosonic experiences.

Temporality	**Initial moment**	**In the moment**	**Shared moment**	**Beyond the moment**
Experiential quality	Exploration of eating sounds	Self-expression via eating actions	Relatedness of eating together	Reflections on everyday eating activities
Design examples	iScream! WeScream! Sonic Straws	iScream! WeScream! Sonic Straws	WeScream! Sonic Straws	Sonic Straws
Design features	**Incongruence of sounds** can elicit curiosity	**Ambiguous** interface can direct attention back to eating/drinking actions	**Independent devices with an interdependent sound system** can prompt new ways of eating/drinking together	**Personalisation** can give space for reflection
	Ephemeral nature of food can facilitate sound exploration	**Looseness of control** can facilitate musical self-expression	**Amplified sounds** can surprise bystanders through an eating/drinking spectacle	**Integration of** a gustosonic experience into everyday eating/drinking activities can be a source of happiness

Figure 1.2: The design framework of playful gustosonic experiences

1.5 Research objectives

In order to answer the research question, I have engaged with the following three research objectives:

Objective 1: Understand the relationship between sound and eating experiences in supporting playful gustosonic experiences.

The first objective investigates existing challenges and opportunities associated with sound in relation to eating/drinking experiences and technology-supported eating experiences by identifying previous works in the fields of HFI, experimental psychology in food, and games and play around eating. This investigation revealed a knowledge gap in understanding how to design playful gustosonic experiences, in particular supporting playful eating experiences through augmented sonic interactions.

Objective 2: Explore the design space of playful gustosonic experiences.

This thesis investigates three playful gustosonic prototypes and the player experiences associated with each prototype by conducting a study. In Chapters 4 to 7, I describe these three prototypes. I also detail their themes and practical design tactics around the design space of playful gustosonic experiences.

Objective 3: Create a theoretical design framework.

Through achieving the above objectives, the outcomes from the three case studies resulted in a theoretical design framework for playful gustosonic experiences. Leaning on prior works on related theories, the framework is derived from an iterative analysis of all findings from the three case studies and the design process of each prototype. Taken together, this has ultimately resulted in the design framework, which aims to guide the design of future playful gustosonic experiences.

1.6 Research scope

I understand the research question of this thesis as exploratory and it could be answered from different perspectives. To better address the research objectives list above and offer a concrete contribution, I have limited the scope of the thesis study to the following aspects:

1. This work investigates the design of playful gustosonic experiences and focuses on the experiential perspective of designing interactive technology within a combined multisensory experience. This work does not focus on facilitating healthy eating goals such

as eating more nutritious food or losing weight, even though this research has potential benefits around healthy eating and could support dietary education efforts. In particular, I believe that this work could inspire interaction designers to create gustosonic systems with instrumental purposes, as it highlights the benefits of considering the hedonic aspects of eating experiences.

2. To study playful gustosonic experiences, I have investigated two types of food material: ice cream and beverages (I focus on soft drinks or soda and in particular water). Firstly, I note that existing studies in psychology report that eating ice cream is a pleasurable experience satisfying both psychological and physiological needs that more "everyday" foods may not necessarily meet (Linley et al., 2013), all while providing people with positive emotions from moderate consumption (Macht et al., 2005). Although the general belief is that ice cream is an unhealthy food (Burger and Stice, 2012), I note that ice cream can be used as an effective vehicle to deliver nutrition to older people because of the dynamic texture and melting, creamy mouthfeel (Spence et al., 2019b). Moreover, eating ice cream can also be associated with positive social activity (Hurling et al., 2015). Secondly, I note that players have various preferences on drinking in everyday life. I have not limited (but suggested) the type of beverages in my case study. The reason for this decision was to make a concrete contribution to understanding the playful personalised gustosonic experiences, for example, how players associated sounds with the tastes of beverages.

3. In the three case studies, I did not study the prototypes in any specific contexts; for example, a playful gustosonic system could be designed for a food court or a bar.

4. This work investigates the intersection of play, food and sound. Although sound plays a crucial role in understanding the design of playful gustosonic experiences, I have not focused on a sound design perspective, which often measures mechanical waves, vibrations and other sonic parameters.

5. All the designed prototypes utilised capacitance-sensing technology. I acknowledge that other sensing technology could be used (for example, resistance data can also be used to sense eating). However, I found that capacitance sensing can offer reliable data (in particular in comparison to resistance data) when it comes to sensing eating/drinking actions.

1.7 Case studies

To answer my research question, I have conducted three case studies to explore the design space of playful gustosonic experiences and generate the design framework for guiding future work. In each case study, I designed a prototype that supported one type of playful gustosonic experience: eating-based playful gustosonic experience, social eating-based playful gustosonic experience and drinking-based playful gustosonic experience. To understand the user experience (UX) of each prototype, I invited participants to experience my first prototype in a lab and my second and third prototypes in the wild. I used semi-structured interviews to collect qualitative data and used a thematic analysis approach to analyse the UX. In this section, I briefly describe each case study and the final design framework.

1.7.1 Case study 1: iScream!

FIGURE 1.3: Case study 1 - iScream!

The first investigation is a design prototype called iScream! (Figure 1.3) that dynamically generates four randomly playful sounds (a roaring, crunchy, giggling, and burping sound) in real time when the player eats plain off-the-shelf ice cream. iScream! detects the player's eating actions through capacitive sensing. The sensing data generated is then mapped to different playful sounds. I selected four different sounds based on the four dimensions of playfulness proposed by Boberg et al. (2015), to explore fantasy facilitation, food congruence, anthropomorphism and bodily response. When the player performs a licking-on and licking-off actions, the system randomly triggers one playful sound from the four sounds. If the player keeps licking or biting the ice cream without stopping, the sound continuously plays in a loop. The process stops when the ice cream is not in contact with the tongue anymore. To understand the UX of iScream!, I conducted a lab-based study with 32 participants. The study resulted in two design themes derived from six findings each. These details how players explored different sonic interaction possibilities with their eating actions while the sounds in turn modified those eating actions. The iScream! case study served as an initial exploration of the design of playful gustosonic experiences. Although the first case study demonstrates that designing interactive technology with an edible interface can facilitate playful gustosonic experiences, I found that there was still limited knowledge of the design of technology that supports the social aspects of playful gustosonic experiences. Therefore, in the second study, I designed a playful social gustosonic system by extending the design of iScream! to support two players composing rhythmical sounds via eating ice cream together.

1.7.2 Case study 2: WeScream!

FIGURE 1.4: Case study 2 - WeScream!

Eating together is an important social activity that supports positive interactions (Fischler, 2011). Interactive technology affects not only how people eat, but also the social interaction within the eating context (Niewiadomski et al., 2019; Spence et al., 2019a). My second case study is a design prototype called WeScream! (Figure 1.4). It extends the design of iScream! to two players. The system consists of two capacitive-sensing cones. WeScream! allows participants to interact with rhythmical sounds produced by the act of eating ice cream together. Each player holds one designed cone to create a musical phrase via licking or biting into ice cream. To understand the UX, five pairs of participants were invited to experience the system in an in-the-wild study (Rogers, 2011) for one week. The results show that the system facilitated playful experiences of "hard fun" through eating together, increased participants' awareness of relatedness, and drew shared attention to the ice cream's taste via increased face-to-face interactions. The results for the iScream! and WeScream! suggested that digitally generated sounds can affect in-the-moment eating experiences via eating ice cream individually or with others. However, eating ice cream is an occasional activity in everyday life, as ice cream is considered a pleasurable treat (Hurling et al., 2015; Linley et al., 2013; Spence et al., 2019b). In contrast, drinking, especially drinking water, is a pervasive activity that people repeat multiple times a day. To complement the above findings beyond an individual eating/drinking event, I therefore decided to expand my understanding of how to enrich playful gustosonic experiences by looking into everyday habitual drinking.

1.7.3 Case study 3: Sonic Straws

FIGURE 1.5: Case study 3 - Sonic Straws

Sonic Straws (Figure 1.5) is a design prototype where the player can experience playful personalised gustosonic experiences through drinking beverages (in particular water) via straws. The system allows the player to use personalised sound clips to generate melodies by drinking beverages via two straws simultaneously. The player can move their mouth between the two straws to create a connected melody sequence. I investigated the player experience of Sonic Straws with 8 participants via an in-the-wild study (Rogers, 2011). The study results show that the Sonic Straws system supported self-expression via playful drinking actions, facilitated pleasurable social drinking moments, and promoted reflection on participants' everyday drinking activity. With the case study, I identified three design themes and proposed three design tactics for designing playful personalised gustosonic experiences with beverages. This study helped me to gain a more complete understanding of playful gustosonic experiences and aided in moving towards the design framework for playful gustosonic experiences.

1.7.4 The design framework for playful gustosonic experiences

Through an iterative approach in analysing the findings of the three case studies, my craft knowledge gained from the design processes for three playful gustosonic systems and examining prior works in related fields, I have generated a design framework that is visualized through a 5*4 diagram for designing playful gustosonic experiences (Figure 1.2). The framework consists of four categories: temporality, experiential qualities of playful gustosonic experiences, design examples related to the playful gustosonic experiences and design features of playful gustosonic experiences. Temporality refers to the user's process of experiencing playful gustosonic experiences through four different time spans: the initial moment, in the moment, the shared moment and beyond the moment. The experiential qualities of playful gustosonic experiences can be used to explain the four core interactions that players appreciate in each time span: exploration of eating sounds, self-expression via eating actions, relatedness of eating together, and reflections on everyday eating activities. Finally, I also present design features and implementation suggestions that might support each corresponding experiential quality. This design framework can serve as a design tool for interaction designers when aiming to design future playful gustosonic experiences. However, I do not suggest that this framework is a strict design instruction set for the design of playful gustosonic experiences. Rather, I see this framework as intermediate-level design knowledge (Höök and Löwgren, 2012) between theories and design practices which offers a design space to support designing future multisensory food experiences through playful designs. Therefore, I believe this framework can not only help researchers describe what they might observe through a vocabulary when designing various gustosonic experiences, but also guide designers when making design choices through the design features of playful gustosonic experiences in their practice.

1.8 Contributions

This thesis makes the following contributions:

1. This research contributes to design knowledge by providing details of the implementation of, and insights gained from, the design and evaluation of three playful gustosonic systems.

2. The case studies have resulted in the articulation of four key experiential qualities of playful gustosonic experiences based on the reporting of the resulting user experiences while offering design themes to analyze, and design tactics to create, various playful gustosonic experiences.

3. This research presents a design framework for playful gustosonic experiences. This framework is the first theoretical conceptualisation of how to design playful gustosonic experiences and, along with the practical examples and design features for interaction designers, it can be used to develop their own playful gustosonic experiences.

Overall, the results from the case studies brings practical design guidance that aims to help game designers to create playful experience around food, people from the hospitality industry and food designers who are interested in incorporating interactive technology into their practice to create novel eating/drinking experiences, and interaction designers to design playful interactions in everyday eating contexts. Moreover, the framework for playful gustosonic experiences offers HCI practitioners a structured conceptual understanding of how playful gustosonic experiences can support positive multisensory interactions with food, which may expand the future of multisensory integration experiences.

1.9 Thesis structure

The thesis is organised into the following chapters:

Chapter 1	Introduces an overview of the research, motivation, and thesis statement.
Chapter 2	Presents the literature review as the background and relevant design examples.
Chapter 3	Describes the research methods used during the research.
Chapter 4-6	Details case studies 1, 2, and 3 respectively; each chapter describes the development and the results of the associated case study.
Chapter 7	Introduces the design framework for playful gustosonic experiences.
Chapter 8	Concludes with a summary of the thesis and presents an articulation of limitations as well as future research directions.

Chapter 2

Related Work

In this chapter, I provide an overview of the related works around sound in relation to eating/drinking experiences, technology-supported eating/drinking experiences, playful eating/drinking experiences in HCI, embodied sonic interaction design in HCI and existing theoretical frameworks. I articulate what I have learned from these that helped me to (at least partially) answer my research question. I start with the understanding of the relationship between sound and eating/drinking experiences in the field of experimental psychology, as this has inspired my work. Finally, I conclude with the research opportunities that playful gustosonic experiences offer.

2.1 Sound in relation to eating/drinking experiences

Research on the relationship between sound and eating has emerged in recent years. Prior works in psychology on food and eating experiences have demonstrated that sound plays a critical role when it comes to eating because our perception of food and eating behaviors are profoundly affected by sound (Spence, 2015a, 2016, 2017b). People can perceive food texture through the intrinsic sounds of food. For example, lettuce and chips are described as crispy, whereas peanuts and almonds are described as crunchy (Spence, 2015a; Spence et al., 2019c). Zampini and Spence (2004) conducted a famous experiment called “sonic chips”. The results demonstrated that by merely changing the frequency of a chip’s sound during biting action, people’s perceptions of the crispness and freshness of the chips could be modified. Even if the actual food texture was soft, people could perceive food as crunchy through crunchy chewing sounds (Elder and Mohr, 2016).

Extrinsic sounds related to food and eating (such as background music, environmental sounds and noise) also have a significant influence over our food perception (Spence et al., 2019c). Music and soundscapes can influence an eater's mood when consuming food and this has been understood to affect to some extent also taste perception (Spence and Wang, 2015a). For example, North (2012) demonstrated that when playing music that was powerful and heavy, red wine could be perceived as tasting more powerful and heavy than with no background music.

Meanwhile, research has investigated through many experiments that the sonic properties of music can systematically alter our perception of taste. For example, Crisinel et al. (2012) demonstrated that the perception of the sweetness of cinder toffee was increased with high-pitched sounds, whereas the perception of bitterness was increased with low-pitched sounds. Similarly, Spence and Wang (2015a) showed that the sweetness was increased with sounds that were high-pitched or with music that was legato in articulation. Perception of sourness was increased with very high-pitched sounds and fast tempo, while perception of bitterness was increased with sounds that were lower in pitch and more brassy (Crisinel et al., 2012). Ninomiya (2015) concluded that umami is like a bass note in music. Spence and Wang (2015a) stated that the volume of sounds could match the intensity of sweetness or sourness of wine. Crisinel et al. (2013) demonstrated that participants matched sweet tastes to a piano and woodwind instrument, while bitter tastes were matched with brassy instruments. Watson and Gunther (2017) reported that people perceived bitterness associated with a trombone rather than the sound of a clarinet. Mesz et al. (2011) showed that musicians could improvise consistent musical patterns for basic tastes (sweet, bitter, sour and salty). For instance, improvisations of sweetness were consonant, slow and soft, bitter improvisations were low-pitched and legato, sour improvisations were high-pitched and dissonant, and salty improvisations were staccato. Furthermore, Spence et al. (2014) showed that congruence between the sounds and wine could influence tasting experiences. Spence and Wang (2015a) asked participants to taste two different glasses of wine, and for each wine they presented the same pairs of adjectives (such as young/old, day/night, etc.). The participants were then asked to choose one adjective of the pair that best matched the wine. The results revealed that participants chose adjectives significantly more often to match higher-level descriptive characteristics of the wine (Spence and Wang, 2015b).

Music has been reported to affect pleasure and emotions while also affecting the perception of taste. For example, Kantono et al. (2016a,b) demonstrated that listening to liked music could evoke the sweetness and mildness of ice cream, while disliked music evoked the perception of bitterness and vanilla flavour. Ziv (2018) showed that cookies tasted better with pleasant background music compared to unpleasant music. Moreover, Carvalho et al. (2016) reported that people rated the flavour of beer as tasting sweeter when listening to music associated with positive emotions, while the same beer was rated as bitter and having a higher alcohol content when listening to music associated with negative emotions.

Overall, these works suggest that sounds can affect taste and hence has great potential to contribute to our eating/drinking experiences. However, these works have focused more on measurable sound stimuli than on the eating/drinking interactions that might occur when people perceive those stimuli. From these works, I learned that there is a missed opportunity where sounds can be used as a design resource when it comes to designing eating interactions.

2.2 Technology-supported eating/drinking experiences

In the field of HCI, prior works have explored using interactive technology to support eating/drinking experiences in many different ways. I distinguish between the use of interactive technology in eating/drinking for instrumental purposes (e.g. healthy eating, diet education) and for experiential purposes (e.g. entertainment, pleasurable experiences).

2.2.1 Learning from an instrumental perspective of technology-supported eating/drinking

Existing works in the field of HCI focus more on building system-centric eating/drinking systems with interactive technology or supporting healthy eating behaviours. For example, Narumi et al. (2011b) designed “pseudo-gustatory” and “Meta Cookie” systems that allow users to change the food colour, texture, and size while eating in AR. Hashimoto et al. (2006) proposed a virtual drinking system called “Straw-like User Interface” that allows the user to experience virtual drinking via replicating pre-recorded sounds of drinking through a straw. Kadomura et al. (2014) designed “EducaTableware”, which includes two digital cutlery pieces, a fork and a cup that can emit sounds during eating and drinking. The system has been used to guide children to consume more vegetables and educate children with healthier eating habits through sound. Similarly, Ishikawa et al. (2017) designed “TamaPeeler”, a cooking tool that detects the act of peeling vegetables and makes various peeling sounds in response to peeling actions. This system has been used to motivate children to touch food directly and raise their interests in dietary education. Moreover, Ranasinghe et al. (2017b) designed “Vocktail”, an interactive drinking system that utilises electrical simulation to augment the existing flavours of beverages. “FunRasa” produces artificial taste sensations through a

3D-printed straw and a control module that overlays colours on a beverage and stimulates the tongue using electrical stimulation via the straw (Ranasinghe et al., 2014). The "Affective Tumbler" conveys thermal sensations to the nasal area to stimulate the skin's temperature response during drinking; users can experience pleasant or unpleasant feelings from the change in skin temperature attributed to the beverage (Suzuki et al., 2014). Furthermore, "Virtual Lemonade" teleports a soft drink via replicating its colour and pH value remotely using plain water (Ranasinghe et al., 2017a). These works show that various technologies have been explored in facilitating eating/drinking experiences for individuals. However, these works have focused mainly on the technical implementation perspective and study in the lab, and there is limited knowledge around how to design for and study the UX in the real world.

As eating/drinking is an important social activity that facilitates positive interaction (Fischler, 2011; Spence, 2017b), HCI research has explored how interactive technology can enrich the social eating experience. For example, Barden et al. (2012) developed a distributed dinner system to facilitate experience of a sense of "togetherness" and "playfulness". Similarly, Wei et al. (2011b) developed "Co-Dine", a connected dining table to enable social eating experiences for remote family members. Nawahdah and Inoue (2013) designed "Kizuna", a tele-dining system to enrich diners' social interaction and increase "enjoyment" between a local and a remote person through eating. Moreover, Leong et al. (2019) designed a dynamic table centrepiece called "Social Bowl" that promotes positive social dynamics and encourages social exchange while eating together.

Overall, these prior works highlight the potential in designing interactive technology to enrich the eating/drinking experience. However, these works focus more on a system-centric design that uses technical implementation in supporting the instrumental aspects of eating/drinking interactions or aims to augment specific sensations of taste. Therefore, in the next section I describe how I also looked into designing technology-supported eating experiences from an experiential perspective to learn from how to facilitate desirable experiential qualities while designing technology for eating/drinking.

2.2.2 Learning from an experiential perspective on technology-supported eating/drinking

Following Grimes and Harper (2008), who have argued for designing more "celebratory technologies" that celebrate the positive and pleasurable aspects of interactions with food, the experiential perspective on designing interactive technology in supporting eating experiences has gained growing interests in the field of HCI. For example, Khot et al. (2017) introduced a 3D-printed chocolate eating experience, where 3D-printed chocolate is used as a reward to facilitate reflection on people's physical activity. Wei et al. (2011a) designed "FoodGenie", which the user can use to customise messages and patterns in digital material and transform this information into food simultaneously. Ferdous et al. (2016b, 2017) created "TableTalk" and "Chorus", which transform personal screens into a shared communal display on the dining table to enrich social eating for co-located diners. Nabil et al. (2018) developed "ActuEating", a shape-changing interface that changes shape and colour in response to diners' actions in order to enrich the social eating experience. Furthermore, Choe (2019) investigated a Korean livestream phenomenon called "Mukbang" where a host eats alone while interacting with viewers over the internet. Anjani et al. (2020) explored technology-supported eating with others for remote social eating through synchronised Mukbang streaming. These works have shown that interactive technology can be used to facilitate positive aspects of interactions with food beyond instrumental purposes (e.g. increasing nutrition intake, correcting eating habits). Therefore, with this thesis I aim to design interactive technologies with food so as to design more "celebratory technologies" (Grimes and Harper, 2008) and facilitate more experiential qualities of eating interactions, in particular playful eating experiences.

2.3 Playful eating/drinking experiences in HCI

I have noted that designing playful interactions with food is not new and the play-focused HCI community and some art performances have especially contributed to this knowledge. For example, Murer et al. (2013) designed a novel lollipop system called LOLLio that can dynamically change the flavours of a lollipop while the player eats the lollipop in real time. Arnold et al. (2018) developed a virtual reality (VR) game called "You Better Eat to Survive" that utilises the chewing food noises as a game controller to enrich a VR game experience. Polotti et al. (2008) designed a sonically augmented dining table called "Gamelunch" that allows people to experience continuous sound feedback while having lunch; the dining table stimulates new ways of manipulating the cutlery and challenges the interaction with cutlery in an expressive manner. The artist Baltz (2021) designed "Lickestra", which is a musical art performance where performers improvise various baselines and tones through actions of licking ice cream. Moreover, Khot et al. (2015) designed a playful drinking system using colourful sports drinks as palatable visualisations of physical activity to not only to replenish but also entertain people after exercise. A public drinking facility called "Drink Up Fountain" (Lieberman, 2021) can talk to the user when they are drinking water. When the user's lips touch the water, the fountain emits vocal sounds and tries to converse with the person in a playful manner. Furthermore, Koizumi et al. (2011) introduced "Chewing Jockey," a playful headset that detects jaw movement and plays back pre-recorded food sounds while the user eats. This work suggested that playing back sounds created by virtual creatures' screaming could provide users with a playful eating experience when they are chewing gummy sweets. I learned from these works that food materials have been involved in various playful interactive eating/drinking systems that support novel interactive eating/drinking experiences.

Prior works have also focused on designing playful eating experiences in social situations. For example, Mehta et al. (2018) designed an augmented eating system called "Arm-A-Dine" that uses wearable robotic arms attached to players' bodies to playfully engage co-diners with the food and each other. Arza et al. (2018) designed an AR game called "Feed the Food Monsters!" that motivates proper chewing technique in a social dining context. The game detects chewing actions through electromyography sensors attached at the jawline and the captured data is converted into virtual food which feeds virtual monsters, then this interaction is mapped onto the co-player's body. An interactive art project is "Pixelate" (Kumar, 2021), inspired by the digital game "Guitar Hero", where players compete to consume the most fruit in the correct order within one minute. The focus here is not on eating itself, but rather as a way to encourage people to eat more healthy foods through social play. Moreover, Mitchell et al. (2015) designed "Keep Up With Me", an augmented dining table which draws on the synchronisation that can often occurs between diners through raising and lowering the bowls of two diners in synchrony. Khot et al. (2019a) presented a speculative robotic design called "FoBo" that acts and behaves like a human as a dining companion in solo-dining contexts.

From these works, I learned that interactive technology can indeed enrich playful eating experiences in both individual and social situations. Although existing work like "Chewing Jockey" (Koizumi et al., 2011) has already investigated playfulness associated with sound-related eating experiences, "Chewing Jockey" is a technical investigation into the detection of jaw movement through a photo reflector attached to the human face, where the system plays sounds through headphones while the user chews food. The premise of "Chewing Jockey" is that playing fantasy sounds while chewing gummy sweets could provide users with playful eating experiences. Therefore, there is still a need to complement these prior technical and artistic works with a set of structured design articulations of how to use sounds as a design resource for playful eating experiences.

2.4 Embodied sonic interaction design in HCI

The use of sound has a long history in the field of HCI. According to Rocchesso et al. (2008), sound can be considered an "active medium that enables novel phenomenological and social experience with and through interactive technology" when the authors investigated sound as a means for designing interactions between humans, digital technology and the contexts. Through analysing the ways people perceive sounds and interact with sounds, prior works studying sonic interactions have focused on linking sounds with the possibilities of interactions and how sound knowledge contributes to designing such interactive systems, for example, the application of sonic interaction ranges from auditory and tangible interfaces (Boem, 2014; Lemaitre et al., 2009; Schiettecatte and Vanderdonckt, 2008), game design (Alves and Roque, 2011; Ekman et al., 2005; Miller et al., 2007), medical research and rehabilitation (Houben et al., 2020; Istrate et al., 2006; Rassinoux et al., 1995) and interactive sonification (Barrass, 2016; Hermann et al., 2011; Roddy and Furlong, 2015). Based on the theory of embodied interaction design, Franinović and Salter (2013) proposed that embodied actions and perceptions plays core roles in sonic interaction design, namely, "how action can be guided by sound in a concrete, lived manner". Therefore, prior works have investigated the relationship between actions or types of interactions and sounds in understanding embodied sonic interaction. For example, Ishii (2004) designed the "MusicBottles" interface, which allows users to open bottles to release the sounds of specific instruments. The user can experience the bottle interface as an instrument, facilitating enjoyment while engaging with the interface. This study showed how sound can create novel interactions with everyday objects. Houben et al. (2020) designed "Vita", a pillow-liked soft interface for people with advanced dementia. These patients have access to everyday sounds through interacting with the soft interface, while the everyday sounds can facilitate playfulness and meaningful engagement by evoking past memories and emotions. Heshmat et al. (2020) designed an asynchronous storytelling system that allows family members to share activities over a distance in different time zones. The system consists of three different devices that contain different sound content. The study showed that recorded voices and soundscapes played in homes can create strong emotional reactions so as to support social interactions and connect people. These explorations highlighted that the affective dimension of sounds can be used to encourage certain forms of interaction and afford new forms of interpersonal interaction.

Overall, inspired by these works, I believe that sound can be a meaningful design resource in facilitating positive interaction and I focus on the context of eating/drinking.

2.5 Learning from existing theoretical frameworks

In the field of HCI, frameworks offer a better understanding in terms of systems, related theories, and the UX of using a system, and usually include a set of design guidelines or design strategies that were typically derived from empirical studies (Hornecker, 2010; Mueller and Isbister, 2014; Mueller et al., 2021). The contribution of this thesis is in a form of a theoretical design framework. To generate this design framework, I have learned from related design frameworks that motivated me to focus on the related play theories as a theoretical foundation during the design process.

2.5.1 Technology as experience

As technology has become more integrated into our everyday lives, McCarthy and Wright (2004) draw on pragmatist philosophy, which stresses the emotional, subjective and transformational aspect of experiences to argue for "four threads" of experiences when designing technology for contexts outside the workplace. The sensual thread is that a UX can link to sensory engagement. The emotional thread is about a positive or negative emotion related to the experience. The compositional thread is the relationship between the parts and the overall experience. The spatio-temporal thread is concerned with how the experience relates to the user's past, future, and present, and the location where the experience takes place. In addition to these four threads, the authors also proposed six aspects that support a discussion regarding seeing UX through a temporal lens. The six aspects of a UX with technology are described as: anticipating (e.g. expectations of users before using a system), connecting (immediate responses to the system), interpreting (making sense of the experience in a more conscious way), reflecting (reflection on the experience in retrospect), appropriating (reusing the system or not), and recounting (storytelling the experience to others). This work highlights that the design of interactive technology should focus more on experiential qualities rather than the functionality. This inspired me, and I also took from this that the temporal aspects are very important; hence I have utilised temporal perspectives in my framework, which I will explain in detail in Chapter 7.

2.5.2 The temporality of the user experience

UX is always characterised by its dynamic and variability of experience, which means UX is not a fixed phenomenon but changes over time for users (Law et al., 2009). Prior work in HCI has already proposed that a temporal perspective on UX plays an important role in understanding technology design because time is seen as a connection between technology and science, offering an understanding of phenomena and supporting the creation of devices to support them (Rapp et al., 2021). For example, Karapanos et al. (2009) presented a theoretical model called temporality of experience that describes four phases of UX: anticipation, orientation, incorporation and identification. The authors also emphasised six design qualities of UX depending on the stage to help in evaluation of a design over time. Similarly, Pohlmeyer et al. (2009) introduced an approach called ContinUE that presents four experiential episodes spanning an overall UX lifecycle. This model proposes: the anticipated experience, user experience, reflective experience and retrospective experience. Moreover, the temporal dimension of the experience defined by the International Organization for Standardisation (ISO 9241-210) (de Normalisation, 2010) describes three phases: anticipated use, during use and after use. Although these works broadened my understanding of the temporal aspects of UX, they do not focus on explicit design possibilities for the creation of food-related technology.

2.5.3 Technology for play

Researchers and designers in the HCI community in games and play have presented several design frameworks for designing technology for diverse play (e.g. social play, wearable play, bodily play, etc). For example, Márquez Segura et al. (2013) identified a design space for body games and suggested considering technology affordances as an important design resource for social play design. Altarriba Bertran et al. (2020) proposed the bridging concept of “Technology for Situated and Emergent Play” that argues for designing technology to support playful engagement that emerges from everyday activities outside leisure and enrich the social and emotional values of these activities. Moreover, Buruk et al. (2019) proposed a design framework to illustrate the possibilities for the future of wearable devices for playful interaction design. Rogers and Muller (2006) proposed a conceptual framework based on sensor-based interactions to help designers and researchers develop novel playful UX. Furthermore, Mueller et al. (2020a) presented the design concept of “bodily integrated play” that illustrates how bodily integrated technology can facilitate playful experiences and proposed a set of design tactics for designing bodily integrated play. These works show how a design framework along with design tactics can assist researchers when designing different technologies for play. These works motivated me to consider designing technology for food play during the design process and inspired me to consider both individual and social aspects of play designs.

2.5.4 Four product pleasures

The four product pleasures framework was proposed by Jordan (2000) who argued that the qualities of an interactive product should go beyond usability and functionally. Inspired by the anthropologist Lionel (2017), the author claimed that there are four types of pleasures that can be found in all cultures. Jordan translated this argument into a design framework for designing a product. The framework consists of four pleasure perspectives: physio-pleasure, psycho-pleasure, socio-pleasure, and ideo-pleasure. Physio-pleasure refers to the ability of a product to evoke physical pleasure derived from the sensation. Psycho-pleasure describes the ability of a product to provide an emotional experience as a reward, such as experiencing flow or fulfillment. Socio-pleasure is about the ability of a product to evoke pleasure by supporting social experiences. Ideo-pleasure argues that a product can be associated with users' beliefs, values and ideals. Although the author suggested that this framework can be used as a guideline at different stages of the development of a product, the framework lacks specific empirical design knowledge for designing product pleasures. From this work, I have learned that the empirical design knowledge should not be overlooked while designing pleasurable experiences, in particular, playful eating/drinking experiences with technology.

2.5.5 Playful experience framework (PLEX)

Playfulness has been regarded as a part of pleasurable experiences in interaction with a product (Arrasvuori et al., 2011). Based on the understanding of pleasurable experiences, game experience, emotions, and elements of play, Arrasvuori et al. (2011) proposed the playful experiences (PLEX) framework, which consists of 22 playful experience categories for designing interactive products to be used in a playful manner. For example, the experience of exploration refers to the investigation of an object or situation when designing a product to perform an action in a surprising way. According to the authors, the PLEX framework can either identify different aspects of playful experiences associated with Jordan's four pleasures respectively or advance designers' understanding of user interactions at a different timescale. For example, when designing for the playful experience of completion, which refers to finishing a major task, the experience of completion occurs when the user is close to an earlier tension associated with feelings of achievement and designers could draw attention to the episodic experiencing of playfulness. Although this framework does not guide designers in designing playfulness in food-related technologies, prior work has investigated designing playfulness in helping chefs to extend play in gastronomy (Wilde and Bertran, 2019). This work shows how 22 types of playful experiences from the PLEX framework afford a broad range of emotional experiences associated with meals and highlights playfulness as a desirable quality of eating experiences when embracing technologies into the context of cooking. As such, the design framework of this thesis draws from the PLEX framework as it illustrates what types of playful experience can be elicited while designing playfulness in interactions with food-related technology and extends this prior work from cooking to eating.

2.5.6 Crossmodal correspondence and sonic seasoning

The term "crossmodal correspondence" refers to non-arbitrary associations between two different sensory modalities (Spence, 2011). For example, people can match high-pitched sounds to smaller, brighter objects placed at higher locations in space and low-pitched sounds to larger, darker rounder objects at lower locations (Spence, 2011). Prior studies in cognitive neuroscience have demonstrated that crossmodal correspondence between different sensory modalities can enhance people's multisensory perception and influence behaviours as people tend to share systematic associations between features, attributes or dimensions of experience across the senses (Spence, 2011). Therefore, there are a few works from which I have learned that have focused on crossmodal correspondence between auditory and gustatory senses in understanding how sounds can influence eating/drinking experiences. For example, Spence (2021) reviewed a set of empirical studies on links between various types of sound and coffee-drinking experiences to propose the emerging concept of sonic seasoning. Sonic Seasoning (Reinoso-Carvalho et al., 2020) refers to music or soundscapes that are selected or deliberately produced to trigger specific effects on multisensory tasting experiences. Building on the framework of crossmodal correspondences (Spence, 2011), the authors summarised that coffee-drinking experiences can be affected by musical parameters (e.g. notes, pitch, timbre, etc.), carefully orchestrated pieces of music, stylistic music (e.g. classical music, jazz), and music's emotional features as sonic sensation transference (Spence, 2021; Reinoso-Carvalho et al., 2020; Spence, 2015b). This framework therefore inspired me to consider the types of sounds in designing the playful gustosonic experiences.

Overall, these frameworks provided insights into my own design framework for playful gustosonic experiences, as they served as examples of how designers generate design knowledge from their findings from studies and offer pragmatic design guidelines for future designers to follow in creating their own novel systems.

2.6 Research opportunity and research question

In this chapter, I have presented an overview of the theories and practical design works that I have learned from for this thesis study. This prior work has shown that there is only limited design knowledge around understanding how to design playful multisensory eating experiences over time. Figure 2.1 shows the intersections of the key research gaps in the literature. My exploration of prior work highlights the specific gap in understanding how sounds in relation to eating experience could be considered a design opportunity to create playful eating experiences through designing interactive technology with food. As such, the research question of this thesis is:

How do we design playful gustosonic experiences?

Overall, in this thesis I address this gap in design knowledge from both a practical and a theoretical view. From a practical view, this thesis considers designing interactive technology with a food focus for a more experiential purpose, facilitating more pleasurable experiences with food via sound interactions. From a theoretical view, current design frameworks have rarely explored designing playfulness in gustosonic experiences, since these frameworks have been generated by designing technologies for diverse play rather than considering how to embed technologies into food materials. As such, there is a need to conduct empirical work to understand how to design playful gustosonic experiences. I will introduce the research methods I have used to address my research question in the next chapter.

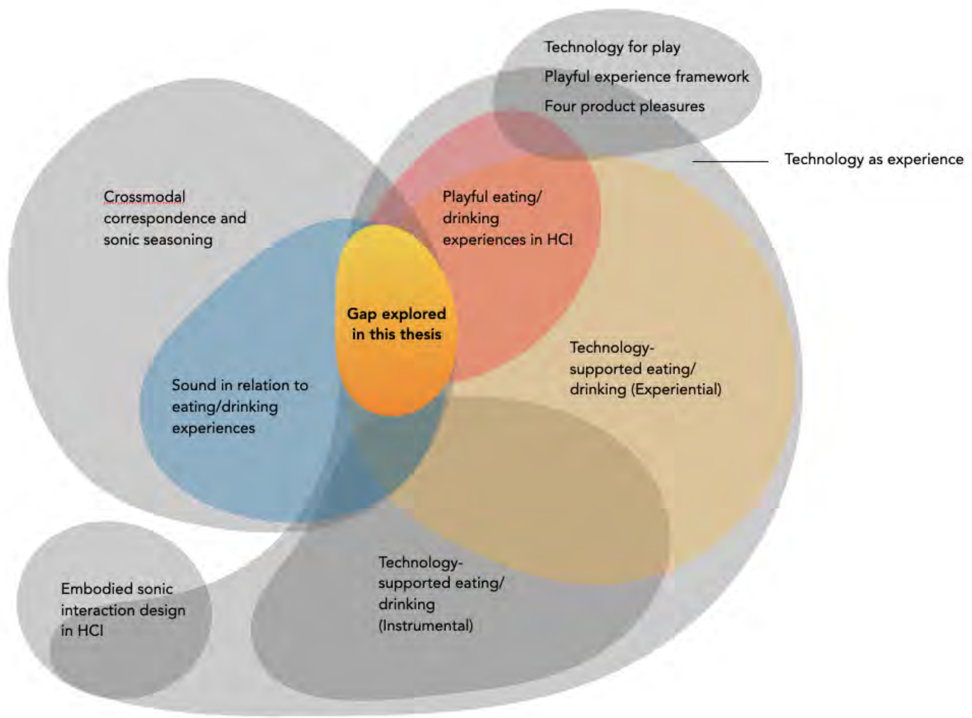

FIGURE 2.1: The research gap explored in this thesis

Chapter 3

Research Methods

THIS thesis steps towards an understanding of the design of playful gustosonic experiences through the design and evaluation of three design prototypes that serve as research vehicles. In this chapter, I present the research methods that I have used in the process of answering my research question.

Ethics approval

All of the case studies in this thesis received ethics approval. My studies of "iScream!" and "WeScream!" received ethics approval from the College of Design of Social Context at RMIT University under the reference number of: CHEAN A 21633-07/18. The study of "Sonic Straws" received ethics approval from the Human Research Ethics Committee of Monash University under the reference number 24232.

3.1 Research through Design

Current studies on food/taste experiences or multisensory eating/drinking experiences often require a precise computer-controlled sensory stimulus delivery device and/or are constrained to a laboratory or desktop setting (Klemen and Chambers, 2012). To understand UX or user behavioural changes, these studies mostly rely on "century-old measurement of user behaviour – accuracy task and latency variables" (Razavi et al., 2020). However, food is not only a source of nutrition for survival and an element of sensory cues for multisensory experiences, but it also serves as a vehicle for enriching our emotional and social experiences in mundane life. Therefore, it is necessary to deploy additional research approaches to study food-related technology experiences. I hope that my approach can help move HFI research beyond laboratory studies into more naturalistic settings.

To answer my research question, I have learned design theories from the field of HCI (Brumby et al., 2016; Rogers, 2012) and followed the Research through Design (RtD) approach (Gaver, 2012; Koskinen et al., 2011) where I designed three gustosonic prototypes in order to understand playful gustosonic experiences. RtD is a reflective approach where new knowledge occurs through prototyping to examine the process, invention, relevance and extensibility of a design (Zimmerman et al., 2007). This approach is popular in the field of HCI because it allows designers and researchers to understand the user's interaction with design artefacts throughout the research and encourages them to "research for the future" (Zimmerman et al., 2010). RtD is a rigorous process of deriving and translating findings into actionable concepts that inform design or generate implications for design iterations. With this approach, the design artefacts of interaction research can "transform the world from its current state to a preferred state". In RtD, the designed artefacts play an important role in understanding why and how the user interacts with the prototypes towards understanding how to design artefacts for the future state (Gaver, 2012). This process ensures that the development of the prototype will be progressively tested and refined over multiple iterations based on feedback from users. The designers, therefore, are not necessarily interested in developing a fully developed system with certain cultural impacts or meeting a specification, but reframe the problem continually and are concerned with why and how the user interacts with the design artefacts (Koskinen et al., 2011). Furthermore, iterative prototyping as a method for research provides opportunities to compare the various prototypes, compare user behaviours between each prototype and connect theories to design work. This process of reflection-on-making can provide insight into more complete understanding, reflection and generation of higher level design strategies for future interdisciplinary discussions. As such, Cross (1982) stressed that designers could consider the question: "How would you design an [X] ?". Inspired by this statement, in this thesis I extend this statement with my own research question: "How do we design the playful gustosonic experiences?"

To answer this research questions, I have used the RtD approach to investigate the design of playful gustosonic experiences. I designed three playful gustosonic prototypes that embed interactive technologies with food materials. The designed artefacts were iteratively developed based on the players' feedback. With this approach, I gained design knowledge from making and evaluating the use of each prototype in order to generate theoretical contributions in the form of a design framework.

3.2 Qualitative study methods used

The main focus of this thesis is to generate a design framework for playful gustosonic experiences that guides designers towards understanding playful gustosonic experiences and creating the future playful designs. Therefore, a qualitative approach (Corbin and Strauss, 2014; Sharp, 2003) was well suited to understand the qualities of playful gustosonic experiences, because this approach can be used to address exploratory and open-ended questions such as understanding the users' behaviours and needs, and studying and analysing the prototypes (Wrigley et al., 2010). Moreover, subjective or open-ended data can be collected in the qualitative research; while following RtD, studies remain open to provide investigators with opportunities to receive unexpected but valuable design insights (Blandford, 2013). Furthermore, a qualitative approach can be involved throughout the design process (Creswell and Creswell, 2017) from interviewing users to understand how they currently engage with the prototype to co-designing prototypes with domain experts and to studying and analysing the designed prototypes.

In this thesis, the case studies of the three prototypes focused on experiential aspects, in particular playful experiences. The data in qualitative research can serve to observe and recreate experiential patterns towards creating design themes, which can contribute to further iterations and strengthen investigations (Creswell and Creswell, 2017; Koskinen et al., 2011). As such, I have adopted qualitative methods to collect and analyse data to understand the UX of the three systems. To develop design themes, I used semi-structured interviews (Drever, 1995) as the data-collection method to gather the data about the UX in each case. To iterate the design artefacts, I conducted group discussion with domain experts as the data-collection method to gather a set of design considerations and design thinking during the design process of each case study throughout this thesis.

3.2.1 Data collection: Group discussion

The co-creation method is a way to get feedback on design ideas and bring people more deeply into the design process because it allows people to communicate and cooperate across different disciplines and diverse fields (Sanders and Stappers, 2008). This method can change the roles of those involved in the design process, for example, the roles of the user, the researcher and the designer. In a classical user-centered design process, the researcher brings knowledge from theories and develops knowledge from user interviews (IDEO, 2015). The designer then translates this knowledge from a report and adds an understanding of technology to generate concepts and ideas (Sanders and Stappers, 2008). However, in co-creation the designer and the researcher can be the same person, as they are given the position of being an expert on their experiences. Their expertise and design skills play critical roles in generating knowledge, iterating ideas and developing concepts throughout the design process. Therefore, a co-creation approach can help to improve the efficiency of the design process and promote a thorough design solution for designing prototypes (Sanders and Stappers, 2008).

I followed this approach at the early stages of designing the three prototypes. I conducted four group discussions for each of the three case studies. The group discussion sessions included seven experts with diverse academic backgrounds: four interaction designers (from general HCI, with two of them also from HFI); one product designer; and two sound designers. For instance, the interaction designers provided insights into how to improve the UX while designing the artefacts of the three systems. The sound designers helped with the development of sound systems for each case study. By drawing from their expertise to discuss and derive ideas, this approach offered me the opportunity not only to get feedback about the design concept from diverse perspectives, but also to capture a set of design considerations to inform the iterations of the prototypes.

3.2.2 Data collection: Pilot studies

The aim of a pilot study is to validate the proposed study procedure, the questions for the interview and the prototype before the real study (Sharp, 2003). A pilot study can help to identify potential issues in advance so that they can be corrected before launching the main study. I conducted a pilot study to finalise the gustosonic system in the case study 2 and case study 3. This approach allowed me to validate that the technical aspects of the two gustosonic systems were working as intended and to understand how users would set up and interact with the prototypes before conducting the in-the-wild (Rogers, 2011) studies.

3.2.3 Data collection: Semi-structured interviews

Interviews can provide researchers with insights and extend the understanding of the UX with a given system (Koskinen et al., 2011; Sharp, 2003). During interviews, participants describe their experiences with the system in the study and share some stories around the system (Blandford et al., 2016). This interview data can help designers to reflect on various aspects of the system and offers deeper insights into the UX (Hassenzahl and Tractinsky, 2006). These valuable insights can further inform the higher level design knowledge as themes later in the process. In this thesis, I have used semi-structured interviews (Blandford, 2013) to gather participants' responses to the three prototypes.

During the semi-structured interviews, I asked participants both open and closed questions. I followed a structured script with a set of questions to guide the interviews, then following up with participants on relevant information during the conversation. The interview questions focused on the participants' expectations, experiences, motivations, feedback on the prototype and use contexts. All the semi-structured interviews were audio-recorded.

3.2.4 Data analysis: Inductive thematic analysis

The method of data analysis I followed in each case was inductive thematic analysis (Braun et al., 2008). The process of thematic analysis transforms collected data into meaningful interpretations related to the system, context, and interactions under investigation (Vaismoradi et al., 2016). The qualitative data analysis usually includes different iterations of the data to discover themes, linking them together to form coherent themes and finally link different themes together to form a coherent story (Braun et al., 2008). A theme is a label that notes something important about the data in relation to the research question. Therefore, thematic analysis offers a theoretically flexible approach to analysing qualitative data allowing the derived themes to be grounded in the data and ensuring that important themes are not missed.

In this thesis, the qualitative data collected in all three case studies was analysed by at least one other researcher and me. After the interviews, I first transcribed the interview data from audio-recordings to text using the NVivo software (NVivo, 2021) . Next, the other researcher and I read the transcripts three times to become familiar with the data and then coded the data independently. Then, the codes were discussed and compared until the other researcher and I reached agreement. These codes were then iteratively clustered into higher level themes.

3.3 Study designs

The study designs for each case study are presented in the following sections.

3.3.1 Participant recruitment

In this thesis study, the recruitment method for all my studies followed a combination of the snowballing method and convenience sampling (Biernacki and Waldorf, 1981). I recruited 32 participants to experience “iScream!”, 10 participants who knew each other before the study to experience “WeScream!”, and 8 participants who knew each other before the study to experience “Sonic Straws”. Prior work in HCI has suggested that the number of participants can be as few as one (Liu et al., 2018) occasionally and more commonly around 10-20 (Blandford, 2013; Drever, 1995) in qualitative studies. Therefore, I believe that the numbers of participants are appropriate in my three case studies as long as enough qualitative data has been collected in the interviews. In my three case studies, I began recruiting participants within my personal network and the lab’s social network (e.g., Google group). I also put posters around the campus to recruit voluntary participants. Based on the snowballing method (Biernacki and Waldorf, 1981), I asked participants whether they could recommend this study to other potential participants.

3.3.2 Case study 1: iScream!

I conducted a lab-based study for case study 1, “iScream!”. A study in a laboratory can provide researchers with the opportunity to focus on a specific variable in a controllable environment (Koskinen et al., 2011). This approach can help to make detailed and accurate observations in early stages of an investigation useful for future inspirations (Koskinen et al., 2011). In my work, I experimented with this approach in the "iScream!" study by developing a lab-based study with 32 participants where I used a within-subject design (Charness et al., 2012), each participant experiencing all the playful sounds in a randomized manner. This approach helped me to understand the technical aspects of the playful gustosonic system and how participants used the prototype in a specific environment. The full details on this study will be presented in Chapter 4. However, the study design for the "iScream!" lacked opportunities to understand how participants would use, adopt and even abandon this novel technology in a real-world context. Therefore, I decided to conduct field studies to understand the UX with the other two case studies.

3.3.3 Case study 2: WeScream!

A field study is a method of investigating the use of a system in a real-world situation with real users in their everyday lives (Rogers et al., 2013). This approach can help researchers to understand the UX in a natural setting, rather than bringing the system to users in an artificial environment. A field study therefore allows researchers to focus on the design in the context of use and collect rich data that informs future designs (Rogers, 2011). The second case study was built on the prior case study by using the same food material. To support multiple devices working simultaneously, I improved the technical connectivity for a cone-to-cone communication. Hence, I conducted an in-the-wild study to understand the UX of the system. The aim of this study was to understand how the playful social gustosonic system would be used in the real world compared to a lab study. The full details on this investigation will be presented in Chapter 5.

3.3.4 Case study 3: Sonic Straws

"Sonic Straws" (see Chapter 6) allowed the players to experience personalised playful gustosonic experiences using personalised sounds via drinking beverages through straws. As drinking activities play a crucial role in people's daily routines, I also conducted an in-the-wild study to understand the UX by deploying the system to the users' homes. The aim of this study was to gather a more comprehensive understanding of the UX of this playful gustosonic system in everyday life. I also presented new design tactics related to a beverage-based playful gustosonic experience.

3.4 Summary

In this chapter, I have presented an overview of the methods that I have used to investigate my three case studies. Following an RtD approach, I designed three prototypes. I conducted a lab-based study for the first case study. Then I conducted field studies to understand the UX in real-world situations in cast study 2 and case study 3. I used semi-structured interviews to collect qualitative data on the participants' experiences and employed an inductive thematic analysis approach to analyse the collected data.

In the next three chapters, I present the case studies (Chapters 4 to 6), detailing the implementation of the designs in order to answer my research question.

Chapter 4

Case Study 1: iScream!

4.1 Introduction

This chapter describes my first case study, which aimed to contribute to my initial understanding of the design of playful gustosonic experiences through a system called iScream!. I designed and studied iScream!, a novel gustosonic system that generates four playful sounds while the user is eating regular ice cream (Figure 4.1). I began with investigation using ice cream because it aligned well with my focus on playfulness, as studies have shown that consuming ice cream can trigger positive emotions (Kantono et al., 2016a; Spence et al., 2019b) and increase the experiences of happiness and well-being (Hurling et al., 2015; Linley et al., 2013). The iScream! system uses capacitive-sensing technology to detect users' eating actions. The system's ice cream cone generates playful sounds based on eating actions. The player is free to perform any eating actions, for instance, biting or licking the ice cream, which results in a variation in sounds. In this case study, I explored my main research question through investigating the sub-research question: *How do we design playful gustosonic systems that use interactive sounds to enrich eating experiences*?

In the rest of this chapter I detail the playful gustosonic system used in this exploration. To understand the UX of iScream!, I deployed iScream with 32 participants. The results are two themes derived from six findings each. These detail how players explored different auditory interaction possibilities with their eating actions while the sounds in turn modified those eating actions.

FIGURE 4.1: The player is experiencing iScream!

4.2 iScream!

iScream! stands for "ice cream screams". The iScream! system dynamically generates digital sounds when the player eats ice cream. I 3D-printed a plastic ice cream cone which hosts the hardware (Figure 4.2). The ice cream is connected to a microcontroller board (WeMos ESP-32) via a concealed piece of removable food-safe aluminium foil that makes contact with the ice cream. The microcontroller sends the capacitive data wirelessly to the custom-made Touch Designer program (Derivative.ca, 2018) via Open Sound Control (OSC), which then generates the sounds played back through speakers. The sensed capacitance value varies depending on the amount of ice cream in the 3D-printed cone.

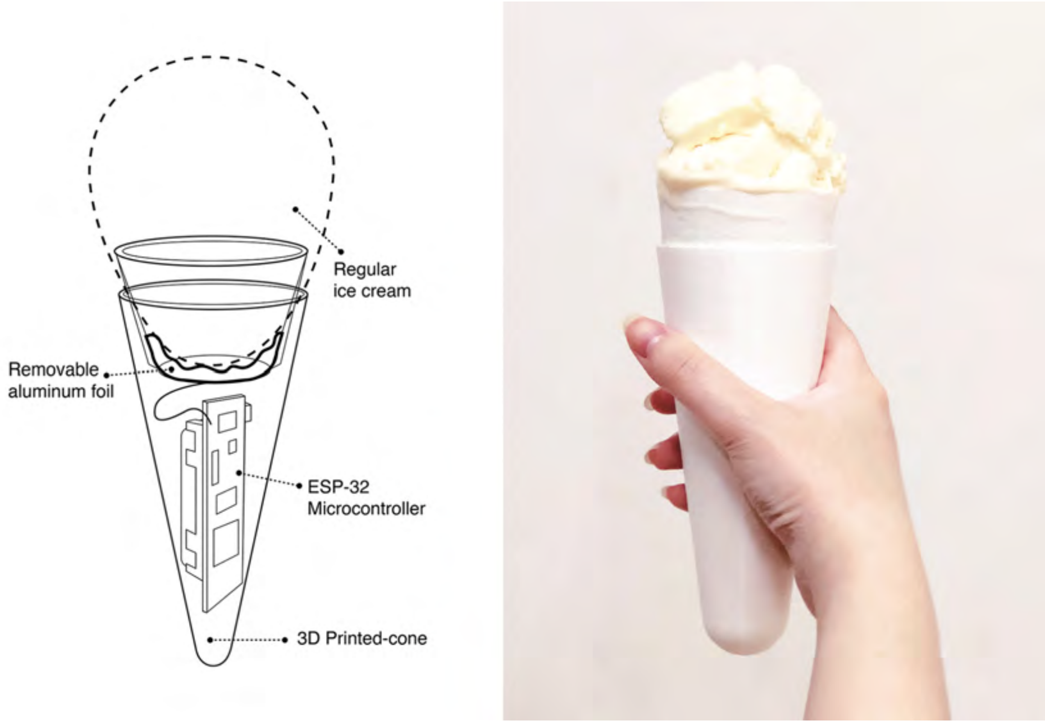

FIGURE 4.2: The 3D-printed cone contains a wireless microcontroller connected to removable food-safe aluminium foil that then makes contact with the ice cream.

4.2.1 Technical explorations of iScream!

Several approaches to sensing eating actions exist in the literature. For example, "EducaTableware" (Kadomura et al., 2014) includes a sensing fork with an integrated three-electrode conductive probe that detects between two tines of the fork and a wired fork grip with an additional electrode. It can only support a fork-type device because of the probe-sensing technology. Another approach is "DinnerWare" (Coelho, 2009), which utilises food's electric resistance to switch on LEDs when a user touches the food through the wired fork. These approaches require wired utensils that may not integrate easily with daily eating scenarios. To address this, I designed a wireless ice cream cone that uses Wi-Fi as I found Bluetooth signals to be less reliable because they are subject to a wide variety of interference (Figure 4.3). Both resistance and capacitance can sense food as food has the attribute of conductivity. However, I found that capacitance offers more reliable data than resistance while eating food without utensils (Wang et al., 2018).

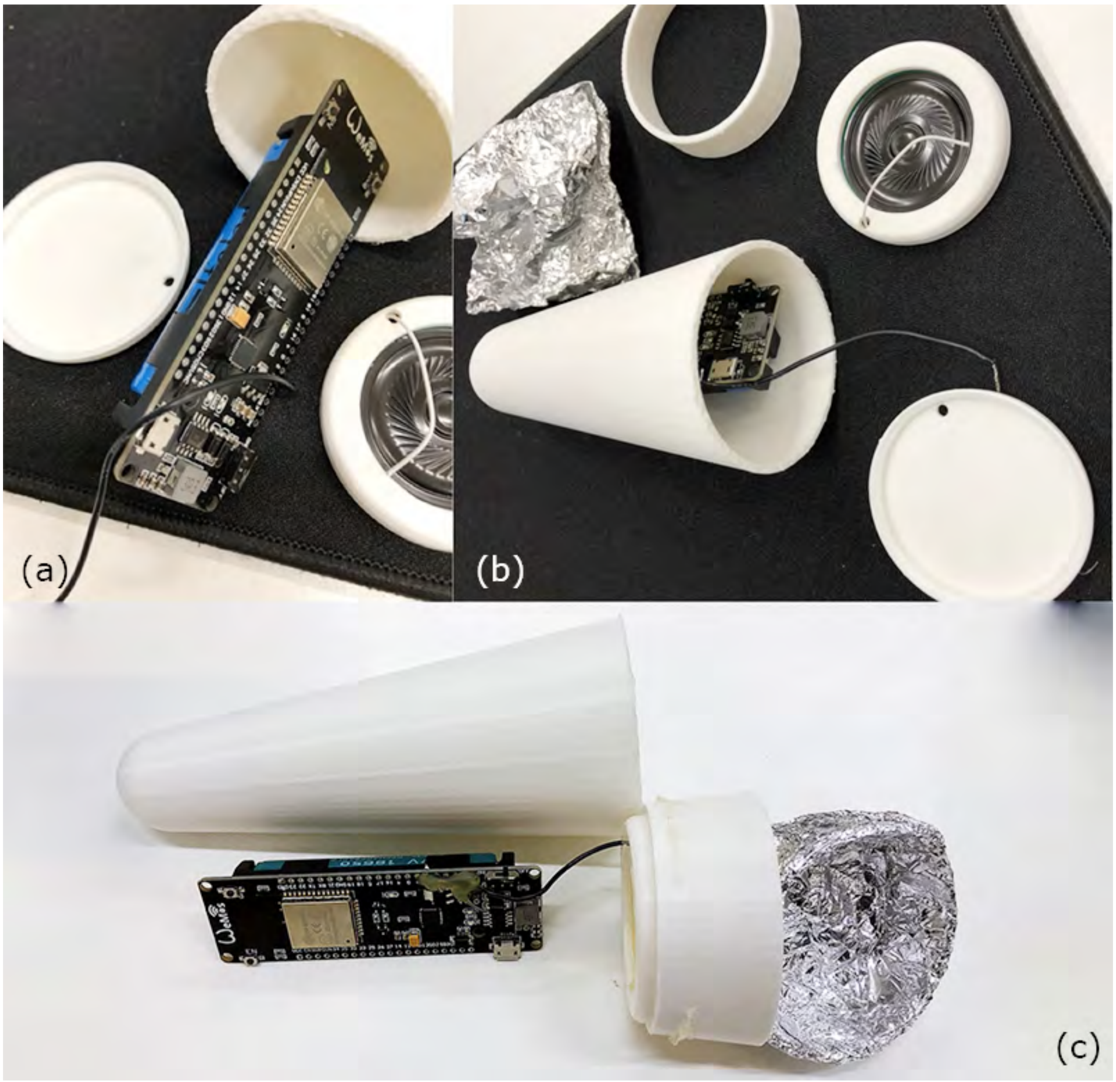

Figure 4.3: (a) The ESP-32 microcontroller; (b) the removable food-safe aluminium connected to the microcontroller; (c) iScream! system configuration.

4.2.2 Rationale for sound interaction

iScream! senses data across the following stages: before ice cream is being eaten, when ice cream is licked and when a portion of the ice cream is being consumed. The detected food capacitance value is then mapped to generate sounds. I normalised the capacitance value within the interval 0.0 to 1.0 in Touch Designer (Figure 4.4). A sound is triggered when the capacitance value is above a 0.65 threshold. This threshold value was identified after 20 trials with different eating patterns during design prototyping. Then I worked with sound designers from our university to set up a sound library of 10 variations on each sound. I began by selecting 60-second sound clips that were edited in the Audacity software (Audacity, 2021), breaking each one of them down into 10 smaller clips. I found that the action of biting or licking ice cream is normally around 0.5 to 0.9

seconds long. First, I used 1-second clips in the initial investigation; the result showed that users needed more time to react to what they heard. After two more rounds of iterations, each clip was shortened to 3 seconds with a 1-second fade-out. When the player performs a licking-on and licking-off action, the system randomly triggers one of the edited variations of the current sound-bank (Figure 4.5). If the player keeps biting or licking the ice cream without stopping, the sound continuously plays in a loop. The process stops after the ice cream is completely eaten.

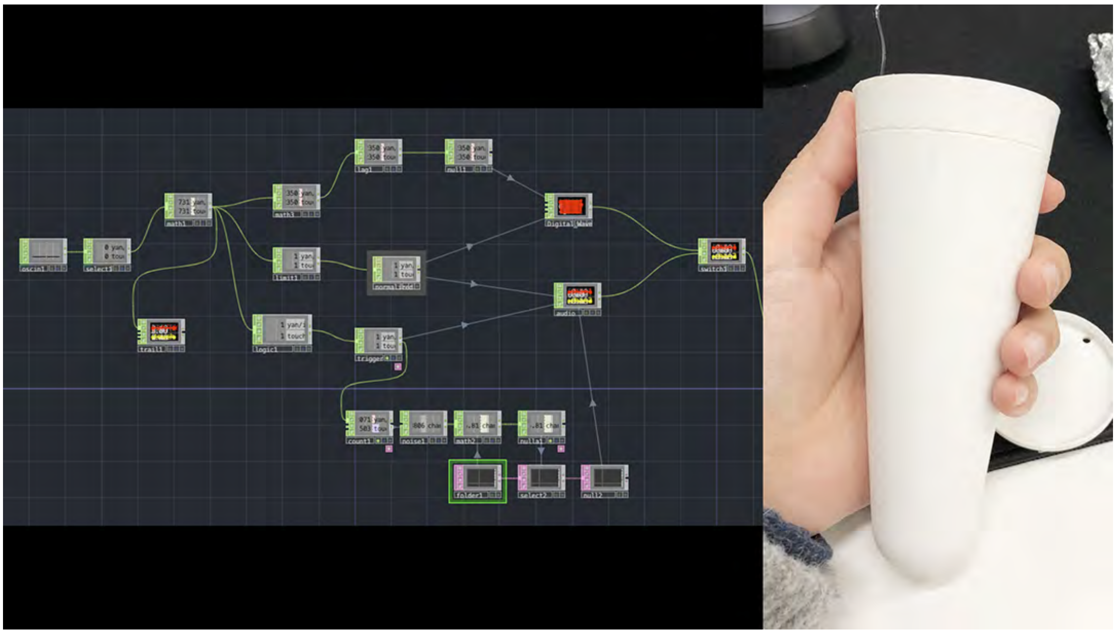

Figure 4.4: The sound system of iScream! in Touch Designer.

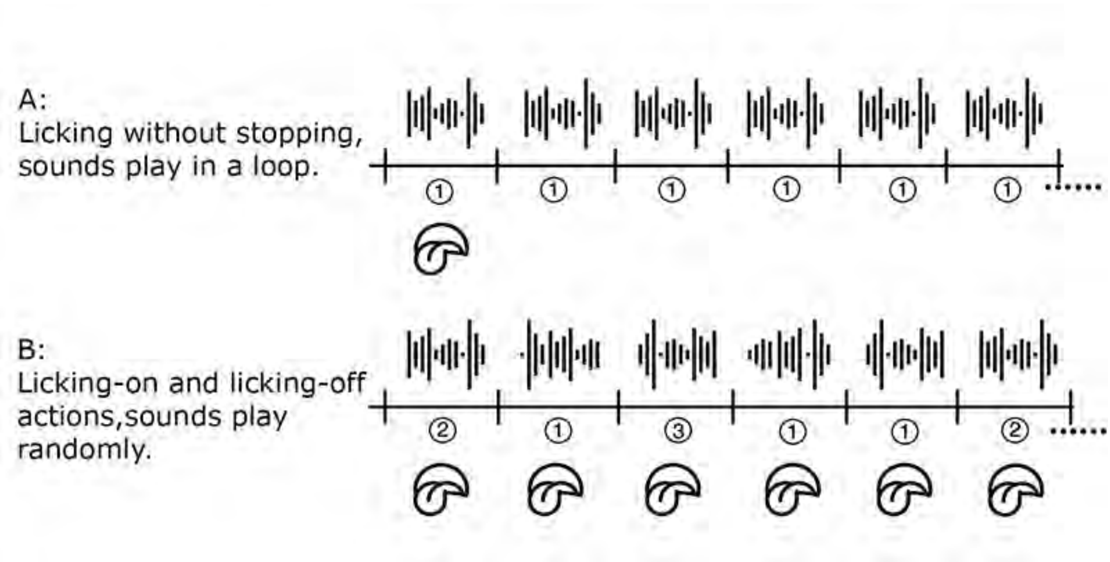

Figure 4.5: The sound interactions of iScream!

4.2.3 Rationale for choice of food material

Studies in psychology show that everyday eating activities, in particular consuming specific "mood food", can provide an everyday source of happiness for most people (Linley et al., 2013). For example, researchers compared the effects of ice cream consumption on mood with the moods resulting from consuming yogurt or chocolate (Walla et al., 2010). The results indicated that eating ice cream is a pleasurable experience satisfying both psychological and physiological needs that more necessary food may not necessarily meet and provides people with positive emotions from moderate consumption (Macht et al., 2005). Furthermore, the general belief is that ice cream can be used as an effective vehicle to deliver nutrition to older people because of the dynamic texture and melting creamy mouthfeel (Spence et al., 2019b). At the same time, eating ice cream may also be associated with a positive social activity (Spence et al., 2019b). These prior works motivated me to investigate the experience of eating ice cream. As such, I believe that designing a playful gustosonic system with ice cream can facilitate engagement with an everyday source of happiness.

4.3 Design process

iScream! was the result of many explorations, extensive prototyping and iterative design. I conducted three brainstorming sessions and group discussions to help refine the design choices and to gather diverse insights into how to sense eating actions and how to select the sounds. The brainstorming sessions followed a co-creation approach (Sanders and Stappers, 2008), including ten experts with diverse academic backgrounds: two industry designers, two sound designers, two game designers, one electrical engineer and three interaction designers (two from HCI and one from HFI). The aim of the first brainstorming session was to identify different possible interaction patterns and decide on the technical feasibility, that is, to identify the right hardware and tools for the system. I discussed different ways to sense eating actions (e.g., motion tracking, wearable tracking devices). Finally I settled on capacitance sensing as it seemed the least intrusive method. Two sound designers helped in creating a library of possible sounds. For the first iteration, I also selected a few food items that included carrots, apples and pears to test sensing technologies.

The focus of the second and third brainstorming sessions was on refining the selection of food items, sounds and interactions based on the PLEX framework (Lucero et al., 2013) and envisioned interaction. These brainstorming sessions involved initial playtesting, where I mapped different food items to different sounds and asked about participants' preferences for each and why. I settled on ice cream, as it offers a more positive experience of eating than the other food items. I also reduced the sound library to 16 and further refined it to 4 based on the PLEX framework.

iScream! can be programmed to play any sound. However, I opted to play four different sounds based on four categories as this allowed me to explore a range while fitting into the time it takes to eat a regular 1-scoop ice cream portion. I was inspired by Wilde (2011), whose designerly approach underpinned the "Hipdisk", a device that allows users the playful opportunity to engage with sounds through a bodily action, not eating but hip movements. Similarly, I aimed to create an engaging playful experience. Based on my team's collective craft knowledge of sounds, I selected a set of 16 playful sounds from an open-source sound library [1]. I conducted a two-hour group discussion with ten participants (7 male, 3 female) that included two sound designers, two industry designers, three senior interactions designers, one electrical engineer, and two game designers. The varied expertise allowed us to discuss not only the options for possible manipulations of digital sound but also their feasibility related to current sensing technologies. I also discussed sound variables such as duration, frequency and intensity (Roads, 2015) and thought about detailed sound qualities, such as a higher pitched giggle or a deeper chuckle. Finally I chose 10 sounds from the set of 16 playful sounds (Figure 4.6).

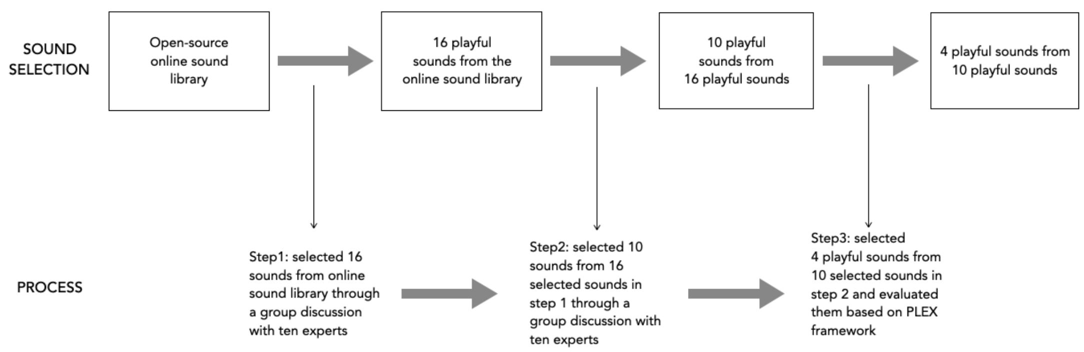

FIGURE 4.6: The design process of sound selection

Then, I conducted a small study with seven users (aged between 20 and 50 years) to examine the tactile experience of holding the prototype and performing eating actions with each of the 10 sounds. Participants verified the design choices and could imagine using iScream! in scenarios such as outdoors, at a party, at home or in a restaurant. I finally narrowed down the categories of sounds related to the four dimensions of playfulness, (stimulation, pragmatic, momentary and negative experiences) as suggested by Boberg et al. (2015). After 70 trials in total, I was able to develop the final set of sounds. I

[1] https://soundbible.com/

believe that the resulting roaring, crunchy, giggling and burping sounds would allow me to explore fantasy facilitation, food congruence, anthropomorphisation and bodily responses (see below). I acknowledge that this list of sounds is not exhaustive and further exploration might lead to more categories; I add that different sounds within a category could also be considered and implemented with the system easily.

Roaring sound: The first playful sound is a roaring sound similar to that of a lion in an animated movie, which I believe enables players to transit into a fantasy world. This was inspired by the “stimulation experience” grouping of “discovery”, “exploration”, “challenge” and “expression” categories in the PLEX framework (Lucero et al., 2013). Prior work found that transiting players into a fantasy world can generate intrigue and curiosity while facilitating positive emotions (Liljedahl, 2011). I hoped players would transit into a fantasy world and feel curious about discovering new eating experiences. Furthermore, I note that a similar kind of fantasy sound is used in the ”Chewing Jockey” system (Koizumi et al., 2011), which strengthened my belief that this might be an intriguing sound category to explore.

Crunchy sound: With the crunchy sound, I wondered how the experience of eating ice cream would be changed if, instead of hearing the licking sound of ice cream, a congruent sound, I played a crunchy sound of eating potato chips, an incongruent sound. The crunchy sound aligned with the “pragmatic experience” grouping of the PLEX framework categories and built on prior work which used crunchy sounds that consists of “completion”, “control” and “competition” to explore digital eating interactions (Spence, 2016).

Giggling sound: The playful sound of giggling was inspired by the “momentary experience” grouping of playfulness, referring to the “captivation”, “humour” and “relaxation” categories of PLEX. Momentary playfulness experiences are associated with temporal pleasurable states where people laugh and release stress (Ryokai et al., 2018). Drawing inspiration from this, I chose a high-pitched giggling sound to add humour. I envisioned that such an anthropomorphised sound (i.e. the ice cream sounds like it is being tickled by the tongue) could support the playful character of the experience.

Burping sounds: I chose the burping sound because I also wanted to consider playfulness as a result of a negative experience (related to “suffering” in PLEX). The idea was to explore a negative bodily response sound as part of a playful eating experience. In particular, a burping sound could operate as a signal that one should stop eating (Roach, 2013). We assumed that burping sounds could create “uncomfortable interactions”, which are traditionally considered bad experiences. However, if uncomfortable interactions are carefully designed, they can offer entertainment benefits (Benford et al., 2012).

4.4 iScream! in action

In the study, iScream! was utilised to gain understanding of the use of four sound categories to support playful gustosonic experiences with ice cream. I conducted a study with 32 participants (13 male, 19 female) to experience four different categories of sounds one after the other. I used a within-subject design for the study, where each participant experienced the four different sounds from the sound categories. I randomised the sequence of sounds for each participant to minimise the learning effect.

4.4.1 Study setup

I recruited participants whose ages ranged over 18-50 years with an average age of 26±4.3 (mean±S.D.) years. All participants had lived in Australia for more than one year. 20 participants were born in China and 12 participants were born in Australia. The participants were all studied in the same city. The cultural backgrounds of the participants are based on the places where they grew up (Global, 2021). There was no financial compensation provided to participants. Before the experiment, participants were asked to complete a pre-study interview where I asked them about their age, gender, food allergies and liking for ice cream. No participants reported hearing loss, eating disorders, allergies to the ice cream's ingredients or health problems associated with eating ice cream. I used a common off-the-shelf vanilla ice cream in the study.

In the study, participants were asked to eat using the iScream! prototype to experience the four different categories of sound. Each sound was experienced in quick succession one after the other. I set up the volume of sounds to 75dB, which is below the level of harmful noise but loud enough to be audible and a level which I hoped would create an immersive experience. I also provided the participants with the option to alter the volume level of the sound. I edited each soundtrack into 10 clips (5s/clip) and set up a random play sequence to facilitate more exploratory experiences.

4.4.2 Study procedure

In the study, I asked the participants to eat ice cream as they would normally do. Each participant started with one scoop ice cream. The participant was free to ask for a refill and they could stop eating at any time. Before I started the study, I told the participants that there were four sounds in random order. Participants could ask to change the sound at any time. The eating part of the study took 20 minutes per participant on average.

4.5 Data collection and analysis

After experiencing iScream!, players took part in a semi-structured interview that lasted between 45 minutes and 1 hour. I asked questions related to the effects of the sounds, expectations, utility and experiences of engaging with iScream!. I also gathered participants' feedback on the overall system design, use of the 3D-printed cone and gustosonic experiences.

All interviews were audio-recorded and transcribed for future analysis. Three independent coders followed the process of the inductive thematic analysis (Braun et al., 2008). Each question and the associated answer represented one unit of data, resulting in 781 data units in total. I examined my interview notes to establish an initial sense of recurring themes and then inductively coded the interview data by developing labels to describe the phenomena. These labels helped to identify the most interesting features of the data unit that were then used to group them together. I iteratively clustered related labels into higher level groupings. Any difference in the results was further refined and discussed between the three coders. In the first iteration of the thematic analysis I developed 82 codes, for example, "Understanding playful experiences of food sounds", and "Changing eating actions". Then I discussed the 82 codes with the other two coders and re-examined them to merge similar codes together in order to reduce the complexity. Through this process I reduced the number of codes to 22. Those remaining codes were refined, re-examined and categorised into groups with the help of two senior researchers. The final outcome of this analytic process includes two overarching themes with six findings each. Overall, aspects of the design facilitated an iteration between exploration and modification, which I present in the findings section next (Figure 4.6).

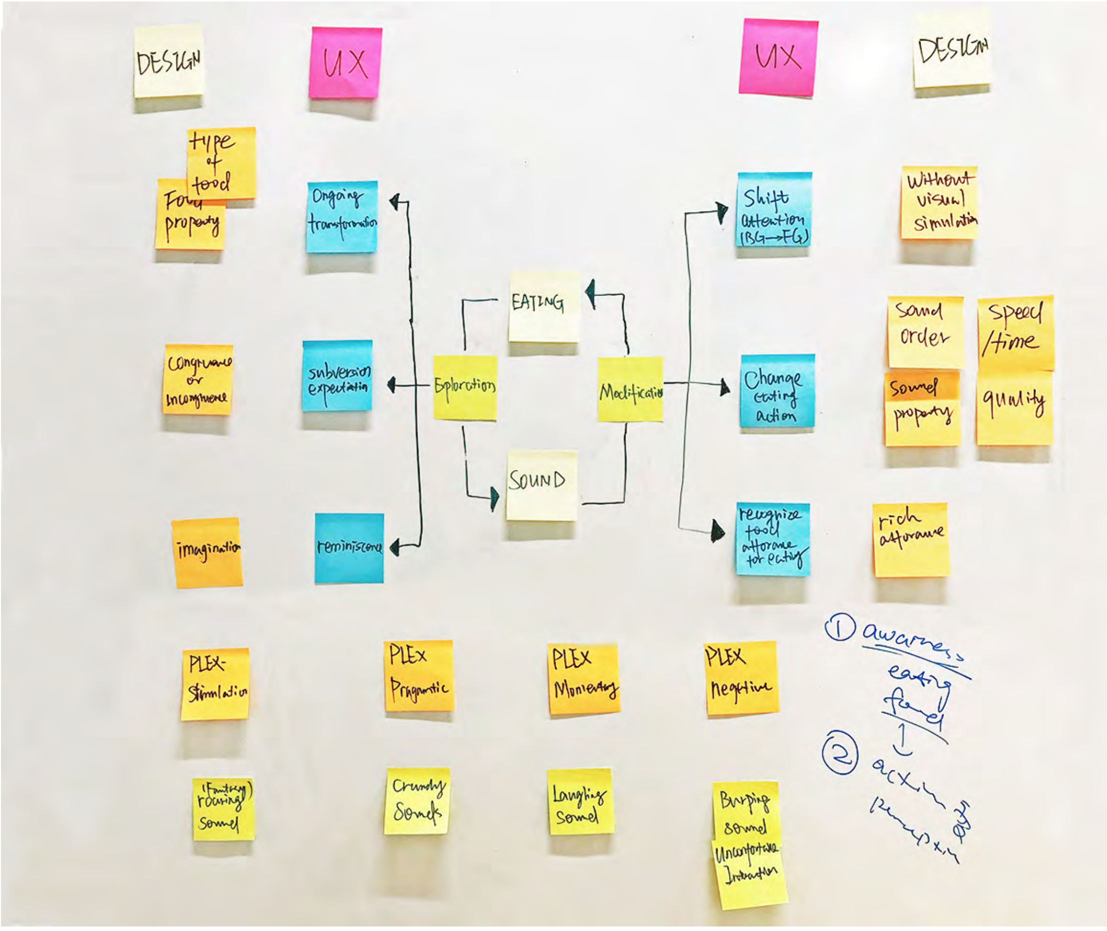

FIGURE 4.7: The process of data analysis.

4.6 Findings

In this section I present the two themes that I derived from the analysis of the interview data. The results detail how the players explored the different auditory interaction possibilities with their eating actions while the sounds in turn modified those eating actions.

4.6.1 Theme 1: Eating actions facilitated the exploration of sound

F1: iScream! facilitated curiosity about what sounds eating would produce. Players found the iScream! experience unusual and markedly different from the usual experience of eating ice cream. Twenty participants felt that eating ice cream in this way offered more "fun" than usual because it facilitated a sense of curiosity about how the ice cream would sound depending on the eating action. They said that the eating process was enjoyable because the sound was always changing. P5 commented:

"Normally when I eat ice cream nothing happens, I keep licking the ice cream until it finishes. Here, there was constant sound feedback, so I was curious about what I could do to control the sounds. It allowed me to focus on: 'How can I play sounds through eating and what kind of sounds would come out?'" Similarly, P23 said: "It puts you through a thought process about what is next? Then, it aroused my curiosity, which sort of sounds would be played next? You were also having fun as sounds keep on changing. It was more like suspense or a guessing game."

F2: iScream! provided additional eating rewards.

Participants enjoyed that sounds were an additional reward to eating ice cream. For example, P1 explained: "Generally, I think ice cream is a treat. Here, I got the ice cream as well as various sounds associated with it that acted as a reward to play with the ice cream. I got enjoyment from both eating and playing with it." This was considered to contribute to the playful character of the experience, even with the burping sounds. P12 said: "I had so much fun with exploring these sounds. It was a genuine, playful eating experience, which one does not often see in food."

F3: iScream!'s exploration was facilitated by the mismatch between sound and eating.

With iScream! there is a mismatch between what people expect ice cream to sound like and what it actually sounds like. Participants found that mismatch intriguing and in response explored the sounds further. For example, P11 laughed and said: "The crunchy sound is a contrast to the sound you normally expect from ice cream. Your mind and taste buds tell you that you are eating ice cream, but your ears remind you that this is not how an ice cream usually sounds." P4 added: "This is so playful. Eating a crunchy ice cream was the most interesting experience according to me. I felt I was playing crunchy soundtracks while I was also eating soft ice cream."

F4: iScream!'s food transformation contributed to sound exploration.

Four participants explicitly described how they adjusted their eating behaviours as a response to the eating sounds because of the ongoing transformation of the food, for example, the ice cream was melting. P20 said: "The ice cream was constantly changing shape as it was melting, and the sound associated with it was varying too." P10 said with a smile: "When I first took a bite the generated sound was slightly different from the second bite, because the ice cream was melting and the shape changing over time." Participants reported that although the messiness resulting from melting ice cream might cause negative experiences, it also facilitated playful explorations. For example, P26 said: "It gets a little messy as the ice cream melts by the time you finish the second sound. But you keep on licking not just to avoid the mess but to allow exploring the sounds."

F5: iScream! facilitated transition into a fantasy world.

Fifteen participants enjoyed the roaring sound as it appeared to transit them into a fantasy world. The study took place during the spring/early summer season: however, the roaring sound reminded players of instances when they had eaten ice cream on a cold day. For example, P16 said: "I felt the roaring sound was soothing, but more like blowing of a wind. I felt like I was eating ice cream at a cool place or in winter. I felt cold." P17 said: "The roaring sound took my mind away from actual eating and I was focused more on identifying what this sound might be. Is it a sound of a lion or a tiger, or is it a wind sound? I was exploring it more than the food itself because it was an exciting sound." Participants also described other fantasy worlds the eating experience transited them into. For example, P19 said: "I liked how the ice cream added another layer to the music composition, definitely a new form of interaction. When I heard the roaring sound, it seemed like I was walking in a field hiding somewhere and observing fierce animals. I felt excited about this." P4 also said: "When I heard the roaring sounds, I felt like I was in a zoo and a tiger was approaching towards me." P22 added how the sound reminded her of video game experiences: "It reminded me of a time when I was playing StarCraft or Heart of the Swarm, where I was on this ice planet, and all these monsters were the creatures that lived in the snow."

F6: iScream! offered relaxation.

Twenty participants felt hearing positive sounds (i.e. the laughing sound, crunchy sound and roaring sound) increased their perception of being more relaxed. P13 compared her previous experience of eating ice cream without sounds: "Normally, I prefer to eat ice cream in a very relaxed situation. But now it is hard to feel relaxed on a regular basis, especially from working. Eating ice cream in stores or cafes is always around noises and there is no playfulness associated with eating. With iScream! there is an inherent playfulness and experimentation associated with the sounds and this makes eating more enjoyable." P6 added: "I think eating is relaxation and sounds like wind-blowing sounds [the roaring sounds] make me feel very relaxed. I like the sounds with some rhythm; this makes me to enjoy the imagination of eating ice cream. It is enhancing my eating experience beyond taste, by bringing in the aspect of sounds."

4.6.2 Theme 2: Sound facilitated the modification of eating

F7: iScream!'s sounds facilitated exploring different ways of eating.

Thirty participants explored different ways of consuming the ice cream to alter the sound generated, for example, touching the ice cream with the lips, the teeth, the tongue and even the fingers. P10 said: "I wanted to see how long I could make the sounds last and hence I was putting my tongue into the ice cream even though it was cold." Similarly, P16 said: "I found that the roaring sound played for a longer time and I wanted to see for how long I could make it roar and see if there was a variation between the sound." P8 commented: "Since the sound changed over time, it encouraged me to have the ice cream in my mouth for a long time, take longer licks." P2 added: "I felt like the frequency of my eating and the soundtrack had a relative connection. When I know I can play these sounds by my mouth or maybe my body, I will try to eat faster or slower as I am curious about what kind of magical sounds can be generated by my own body." Moreover, the giggling sound and the crunchy sound made participants feel like they would consume more ice cream, but the burping was found to be appalling when eating. P13 explained: "I do not like burps. They are disgusting. The burping sound made me feel full. However, I liked the crisp sound. I wanted to keep eating the ice cream. It was like eating chips, but actually I was chewing an ice cream." P10 pointed out: "To be honest, I paid more attention to the sound rather than the taste. The action of holding an ice cream is natural, but ice cream making sounds was different. If any of the sounds made me uncomfortable, I wanted to stop eating." P12 commented: "When playing with the roaring sounds, it was essential to identify and reflect on my eating style and I was able to relate the roaring to my mouth opening."

F8: iScream! altered eating speed.
Six participants reported that their eating speeds was altered by the sounds. P30 said: "I normally eat ice cream in a relaxed, casual way, taking as much time as I can. However, the giggling sound made me eat faster." Similarly, P7 reported: "It was interesting to change my eating speeds by playing with these sounds. I liked the funny burping sound, so I licked slower to have some fun."

F9: iScream! increased food appetite.
All participants finished the ice cream and 25 of them asked for a refill. Ten participants said that the crunchy sounds made them feel hungrier. One possible reason could be that crunchy sounds are typically associated with crispness of food; as such, the crispy crunch as sonic stimulation could have influenced the pleasantness of the food. Ice cream is typically consumed without sonic attributes. However, iScream! can change this. P3 explained: "The crunchy sounds sounded like crispy chips, it made me suddenly hungry when I heard [it], and I wanted to eat more." Similarly, P9 said: "I did not know sounds can affect eating before this experiment. When I heard crunchy sounds, I felt like eating more and I did."

F10: iScream! facilitated playful experiences without visual stimulus.
iScream! did not offer any additional visual stimulus while eating. Fifteen participants mentioned that they normally ate ice cream in front of the TV, mobile phone or computer. They liked how iScream! offered them a non-screen-based interactive experience.

For example, P8 commented: "It did not offer any visual feedback, but I was listening and paying attention to what the sounds were going to change to in a while when I was eating ice cream." P18 added: "This is like a delightful experience that does not rely on a screen for pleasure."

F11: iScream! shifted eating to the foreground of attention.
Fourteen participants said that iScream! encouraged them to pay more attention to their eating. P19 said: "I normally eat ice cream while watching TV and hardly pay attention to how I eat. Here, because of the sound, the eating experience came from the background to the foreground." P23 confirmed: "This feels so novel for me as ice cream is generally taken after your meal just as a dessert, but now I pay more attention to it through these kinds of sounds. It is not just a playful experience, it makes me more aware of my eating." In closing, P18 said: "From now on, I will pay more attention to ice cream and my eating. Maybe the ice cream will suddenly make a sound, who knows?"

F12: iScream! facilitated awareness of eating behaviour.
Players reported that iScream! made them aware of their eating behaviours. For example, P11 explained: "It is interesting to think about how I eat the ice cream with these sounds. To be honest I never noticed that sounds could influence my eating behaviours." P17 also said: "It made me realise the sounds changed my eating behaviours because I knew I was eating slower than I usually do." P21 mentioned: "After this experiment, I might notice background sounds in those ice cream stores that might influence my eating speed or made me buy more ice creams."

4.7 Design tactics

In this section, I reflect on the findings and discuss them based on my craft knowledge gained from designing iScream!. I present four design tactics aimed at providing designers with practical guidance when designing playful gustosonic experiences.

In this case, participants found iScream! very engaging and commented that the system was able to facilitate various playful experiences accompanying their own laughter. The findings appear to confirm the theory by Mueller et al. (2018) that players can experience their body as play (including eating) by shifting the focus between the body (the fleshy body as object) and the lived body (the felt body as experienced) back and forth. For example, the player first tries to put the ice cream into their mouth using their body to consume food. Then the player perceives playful sounds through their eating actions. After that the player explores sounds though eating actions and their attention shifts to their eating actions to better control the sound. Therefore, interaction designers can learn from experiential design knowledge to facilitate an interplay between eating activities and sounds, as this appears to have potential to support experiencing eating as play.

4.7.1 Tactic 1: Support the exploration of sound through incongruent eating actions

Our brain connects information from multisensory input (Spence, 2011), while the sensory information usually corresponds to the same semantic identity (Velasco et al., 2016). In addition, relate information based on the compatibility of crossmodal correspondences. For example, people sense the sound of chewing chips and attribute it to the sound of a fast food restaurant (semantic correspondence). Moreover, when we hear the crunchy sound of chips, the sound may guide our expectations about the quality of the chips (crossmodal correspondence). Congruent experiences occur when our perception equals our expectation. If people experience something different than expected, surprise occurs. Prior work suggested that designing appropriate incongruences can evoke surprise and humour to support playful experiences (Ludden et al., 2012). In the study, before participants started eating, they saw the regular ice cream and related that to something soft and creamy (crossmodal correspondence). Then the congruence between the multisensory experiences (e.g. the taste, tactile experience, melting over time) and the expectation of ice cream is confirmed once people started eating. However, when participants perceived an incongruent sound from the ice cream that differed to what they expected, they experienced surprise, resulting in a playful eating experience.

iScream! engaged with incongruence through interactive sound in multiple ways. The most obvious one is the crunchy sound that is a mismatch with the information from the other senses when eating ice cream. However, the other sounds also engaged incongruence, in particular as evident through the transit to a fantasy world where the fantasy was incongruent with the physical world the participants experienced the food in, so the semantic correspondence was being played with. Eating seems to facilitate this engagement with a fantasy world further, as eating is associated with helping to recall past memories, which can help if the fantasy world relates to a past memory (Liljedahl, 2011). Fantasy facilitation is a common design strategy in game design to support playful experiences (Lazzaro, 2009). I therefore confirm these theories that sound can bring images about a setting, extending it to interactive food sound, and argue that sound can be used to support incongruence to facilitate a playful experience. For example, I had selected a roaring sound in iScream!; however, many participants thought of it as a cold breezing wind sound, which appeared to transit them into a fantasy world where it was cold, reminding them of past experiences where it was cold, with three participants even mentioning the feeling of being cold. I found it intriguing that the selection of sounds could facilitate fantasy elements around food, which then in turn supported an incongruence that facilitated a playful experience.

As such, I recommend that designers could support the exploration of sound through incongruent eating actions as a way to facilitate a playful eating experience.

4.7.2 Tactic 2: Support the exploration of sound by utilising the inherent features of food

Prior work suggested that the inherent features of food (e.g. colour, scent, texture and taste (Stummerer and Hablesreiter, 2009)) can be used as design material to support playful experiences. For example, Arnold et al. (2018) designed a VR game that makes use of the inherent sound food makes when being chewed; for example chewing an apple sounds different to chewing a carrot. This was used to enhance the feedback in the game. Vienna's musicians created a vegetable orchestra (Vegetableorchestra, 2007) that utilised the vegetables' inherent sounds to perform contemporary music. Designers have also looked into the conductive properties of food to support play. For example, the public drinking facility called "Drink Up Fountain" (Lieberman, 2021) can talk to the user when they are drinking water. When the user's lips touch the water, the fountain speaks and tries to converse with the person in a playful manner. Similarly, Murer et al. (2013) designed "LOLLio", which utilises the inherent taste of a lollipop and augments it to facilitate a playful experience. iScream! uses the inherent conductive feature of ice cream and its ongoing transformation as a result of temperature changes to support the exploration of sound through eating actions. Since ice cream melts over time – and participants consume the ice cream, so it changes in volume – there was always a differently shaped piece of food to be explored. As players were licking the ice cream, it made a sound but it also diminished, both through eating as well as melting. As the ice cream was melting, players had to consistently engage with it, which created almost a soundscape rather than individual sounds. So after each lick, the ice cream was different and hence sounded different. This seemed to facilitate exploration, which participants appreciated.

Interestingly, participants also had to accommodate the dripping of the ice cream; they had to change their way of holding the cone and use their fingers and tongue to catch any dripping ice cream. This appeared to further facilitate the exploration of sound, as participants were curious about how the ice cream would sound when touching it with their hand, when ice cream would run over their fingers and so on. This messiness appeared to contribute to the playful character of the eating experience, confirming a prior work that linked messiness with playfulness (Khot et al., 2017).

I recommend that designers could support the exploration of sound by utilising the inherent features of food and in particular the inherent feature that food diminishes when eating as a way to facilitate playful eating experiences.

4.7.3 Tactic 3: Support self-expressive eating actions through varied sound parameters

This study indicates that the highlighting of sound parameters facilitated the modification of eating actions. The potential of these sound parameters, like sound source, pitch, rhythm and phrase structure, is already acknowledged within the practice of composing electronic music (Roads, 2015). Here I extend this to the generation of sounds as a way to support the modification of eating actions; in particular, I randomised these parameters. For example, in the study, participants played with increasing and reducing the pace of licking as well as the amount of ice cream consumption per lick in order to control the pitch of the sound. Furthermore, participants explored licking and biting each time the high-pitched giggle coincided with an eating action. Since I randomised the sound clips of each sound source as mentioned earlier, participants dynamically altered their eating speed and their way of eating. For instance, participants increased their licking frequency to trigger sounds that were different with each bite; as such, the phrase and rhythm appeared to be controlled by the participant. Interestingly, I also found that participants explored opening and closing their mouth as a way to map the source of the roaring sound. By giving participants control over these sound parameters, even if it is only perceived control as in the high-pitched giggle (the participants did not change the pitch, but the eating action made it appear as if it was controlled), designers could support the modification of eating actions. I find that providing this control to an extent where participants are able to express themselves, including the ability to produce "silly" sounds, can be an intriguing way to support playfulness as part of eating experiences.

This aligns with prior work that suggested changing sound parameters to modify eating actions; for example, see a study on music in restaurants that showed that fast-tempo music could increase the number of bites per minute by diners (Roballey et al., 1985). With this work, I highlight that changing sound parameters in interactive sounds can also be used to modify eating actions and, by supporting participants' self-expression through the control of these parameters, designers can facilitate playful eating experiences.

As such, I recommend that designers could support the modification of eating actions through varied sound parameters. In particular, I highlight the potential of engaging with the control of these parameters (e.g. volume, pitch, timbre) in order to support self-expression as a way to facilitate playful eating experiences.

4.7.4 Tactic 4: Support mindfulness towards eating actions through sound stimulation

I found that the extrinsic sounds (Spence et al., 2019c) (i.e., those sounds that are not directly associated with a food or beverage) supported the modification of eating actions. The exploration of sounds appeared to shift players' attention to their eating actions. However, since the sound was changing, the focus shifted back to control the sound with different eating actions. With the roaring sound, participants tried to lick the ice cream continuously in order to make the sound play longer; that way they thought they could identify what type of sound it was and what it reminded them of. With respect to the giggling sound, participants wanted to experiment whether their eating had any effect on the sound volume and frequency. They also increased their eating speed with an increase in the "beat" of the sound and slowed down when the sound stopped. As such, I can say that the extrinsic sound could have resulted in supporting mindfulness of eating actions. I might note that such a shifting of attention is not inherently playful; nevertheless, I believe it is supportive of any playfulness that the other strategies might facilitate.

Interestingly, this modification facilitated a shifting of attention to the food. Participants appreciated that iScream! offered them a shifting of attention towards the food, making them more aware of their eating behaviour, all while appreciating that this was achieved without any visual stimulus. This is especially noteworthy as 15 participants said that they usually ate ice cream in front of a TV, mobile phone or computer. It is commonly believed that screens distract from the experience of eating and that this has a negative impact, leading to eating disorders and obesity (Jacobi et al., 2004; McKetta and Rich, 2011).

With this in mind, I can see instances emerging of using sound-based play to support mindful eating practices. Mindful eating (Donovan, 2018) is the practice of nurturing healthy eating behaviours. Mindful eating emphasises eating without any distractions and assumes that one is eating with the intention of caring for oneself by noticing and enjoying the food. However, instilling such behaviour is challenging in practice. This study suggests that playful gustosonic experiences like iScream! have the potential to support mindful eating practices as they can facilitate a shift of attention towards the food and make people aware of their eating behaviour, all without the negative connotations of screen use during eating. Exploring this further could be an interesting avenue for future work.

In summary, I recommend that designers could consider mindfulness towards eating actions through extrinsic sounds as a way to support a playful eating experience.

4.8 Conclusion

In this case study, I have described the design and study of iScream!, a novel playful gustosonic experience with ice cream. It works with any off-the-shelf ice cream and generates four playful sounds (roaring, giggling, burping, and crunchy sounds) based on licking actions. The user is free to perform any eating action, for example, biting or licking the ice cream, which results in a variation of sounds. A qualitative analysis of a study with 32 participants derived two overarching themes and four design tactics to analyse and design playful gustosonic experiences.

This first case study raised various questions in relation to taking the initial steps towards creating the design framework. This work highlighted the potential for playful gustosonic experiences to enrich playful and novel eating experiences. However, many works in the HCI field have shown that engaging with music and sound can offer rich social play experiences. Meanwhile, eating together is also an essential social activity of everyday life. This suggested to me that a more advanced way of designing playful gustosonic experiences to support collaborative play could be worth exploring.

In the next chapter, I will present WeScream!, which was designed for people to interact with rhythmic sounds generated through the act of eating ice cream together.

Chapter 5

Case Study 2: WeScream!

5.1 Introduction

THIS chapter describes my second case study, WeScream!, which extends the design of my first case study in supporting a social perspective on playful gustosonic experiences. In this work, I present a playful social gustosonic system that allows users to interact with rhythmic sounds generated through the act of eating ice cream together.

FIGURE 5.1: Players enjoying WeScream! together.

Eating is a social activity of everyday life (Fischler, 2011) with the resulting pleasures constituting some of "life's most enjoyable experiences"(Brillat-Savarin, 1835). Drawing on this, researchers have explored the use of eating activities as positive psychology interventions to increase everyday happiness and wellbeing (Macht et al., 2005). Prior studies have also shown that people who engage in social eating feel happier and are more satisfied with life (Fischler, 2011). I found this intriguing and noted that interactive technology is increasingly entering the eating space to facilitate social eating experiences (Niewiadomski et al., 2019; Spence et al., 2019a). The advance of technology affects not only how people eat, but also their social eating interactions. However, some research has regarded this invasion of technology into the eating space as undesirable; for example, we can see a person focusing on a smartphone in one hand while eating with a utensil in the other (Spence, 2017b). In response to this situation, many researchers have proposed that there are also a number of potentially positive opportunities offered by designing interactive technology properly; for example, see Ferdous et al. (2016a); Grimes and Harper (2008); Khot et al. (2019b). As such, the study of WeScream! allowed me to explore how a playful gustosonic system can support social eating experiences.

Prior work around the design of social play in HCI has been utilised to engage people in positive experiences related to "pleasure, social engagement and self-expression" (Isbister, 2010; Lazzaro, 2009; Mueller et al., 2017, 2019). Social play is described as an active engagement with a playful system or a game by more than person at once (Isbister, 2010); in contrast to solo play, social play can provide people with more positive affect and less tension (Gajadhar et al., 2008) . When it comes to designing social play, Isbister (2010) proposed a framework that highlights designing technology that allows for cooperative play to take place among co-located players. Moreover, Segura and Isbister (2015) suggested designing for co-located social play that considers not only the technology but also the "social-spatial context for play" and "the collective experience of fun and social engagement." Many research projects in HCI show that sounds can enrich both social and playful experiences; for example, Tolmie et al. (2013) proposed a study of Irish music sessions where musicians gather together to play in pubs. One player starts off playing a specific tune (e.g. G major and D major) with other musicians joining in the session. These sessions not only allow a number of musicians to collaborate in playing music, but also engage people in social interaction in the pub setting. I, therefore, argue that there could be a design space worth exploring around enriching social eating experiences through engaging with sound while eating together. As such, more design knowledge is needed in order to understand how to design playful gustosonic experiences to support social eating interactions in a playful manner.

Inspired by prior works, I extended the design of iScream! to WeScream! for people to eat ice cream together to generate rhythmic sounds in order to facilitate positive social eating interactions. The name "WeScream!" was inspired by the popular 1927 song or rhyme: "I scream, you scream, we all scream for ice cream". To understand the UX of WeScream!, I deployed WeScream! (Figure 5.1) to five pairs of participants in an in-the-wild study (Rogers, 2011) for one week. The results show that the playful gustosonic system facilitated playful experiences of "hard fun" through eating together, increased participants' awareness of relatedness and drew shared attention to the ice cream's taste via increased face-to-face interaction. In the rest of the chapter, I detailed the playful social gustosonic system.

In this case study, I answer my primary research question through investigating the sub-research question: *How do we design gustosonic systems to support playful social eating experiences?*

5.2 WeScream!

WeScream! is a two-player system offering users the opportunity to generate musical sounds while eating ice cream. Building upon the iScream! prototype, I created the wireless connectivity for cone-to-cone communication. The system comprises two capacitance-sensing cones. Each cone has a miniature speaker inside and a more powerful battery that allows for longer use. I integrated a Bluetooth speaker into the cone which enables localised sound to come from the ice cream cone (Figure 5.2). Each participant holds one cone to create a musical phrase via licking or biting on a regular off-the-shelf ice cream. To enrich the ice cream eating experience, I 3D-printed each ice cream cone using a light wood filament to mimic the look and feel of a regular ice cream waffle cone. The cone contains a microcontroller board (Huzzah32 feather) and a Bluetooth speaker board (Journey Mini Bluetooth speaker) paired with a speaker (Figure 5.3). The ice cream is connected to the microcontroller board via a concealed piece of removable food-safe aluminium foil. The microcontroller sends the capacitive data wirelessly to a Pure Data program (Puckette, 2018) which maps the normalised capacitance data to a major pentatonic musical scale; I also set up automatic calibration of the sensing data to support sensing different types of ice cream. Then the Pure Data program (Puckette, 2018) outputs musical notes to Ableton Live (Ableton, 2021) via Open Sound Control (OSC) that generates a piece of a melody played back through the Bluetooth speaker. I customised a MIDI interface in Ableton Live to control two different instruments that strongly differentiate the two cones. I set up a collaborative way to play with the sounds by adding a chords effect in one of the sound patches to place the final sound outputs on top of each other. Players can try different instruments as offered through the instrument library of Ableton Live with the system during playing.

FIGURE 5.2: (a) The iterative 3D-printed cone; (b) a Bluetooth speaker board paired with a speaker; (c) a light wood filament for the 3D-printed cone; (d) the WeScream! configuration.

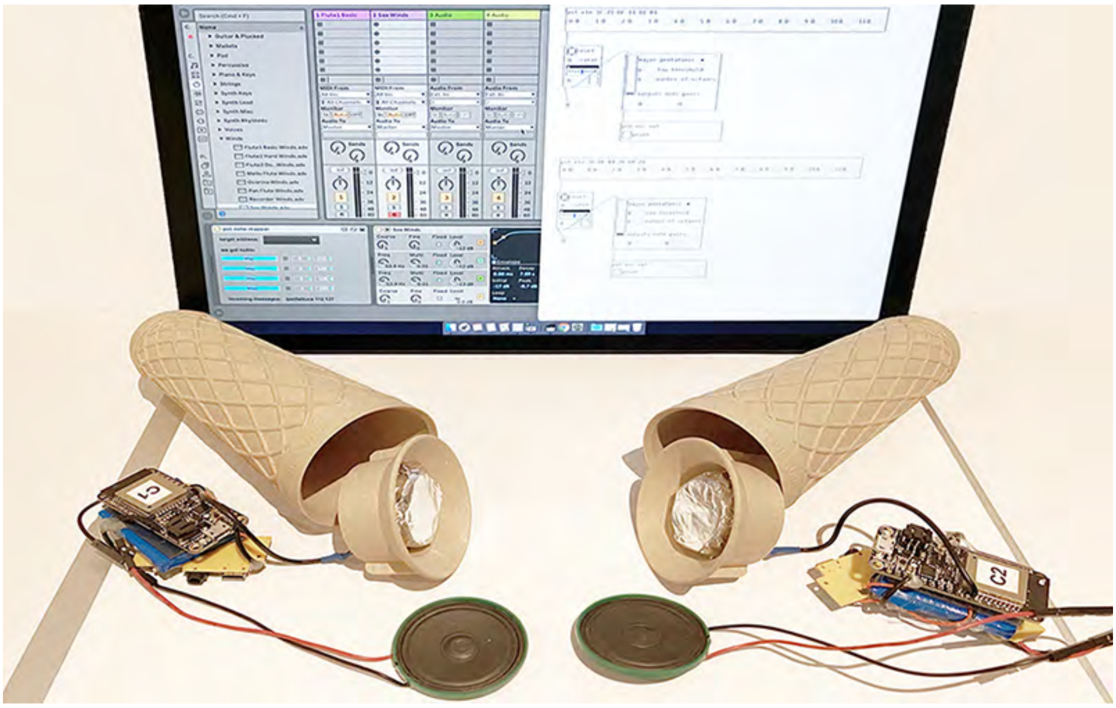

FIGURE 5.3: The WeScream! system contains two capacitance-sensing cones.

5.3 Design process

In this section, I present the design process for WeScream!, the design of the sound system for eating together and the pilot study of WeScream!.

5.3.1 From iScream! to WeScream!

To design WeScream!, I conducted three group discussions following a co-creation approach (Sanders and Stappers, 2008) to help refine the design and to gather diverse insights on how two people could eat ice cream together with sound. The group discussion sessions included seven experts with diverse academic backgrounds: four interaction designers (2 from HCI and 2 from HFI), one industry designer, and two sound designers. The aim of the first group discussion session was to identify different possible social-eating interaction patterns and decide on the technical feasibility. The discussion also focused on the ways that two people eat ice cream together. The discussions suggested that people seldom share one ice cream if they are eating ice cream in a waffle cone. However, people like to eat ice cream together as a social activity, especially females (Spence et al., 2019b). Therefore, a desirable design space appeared to be the design of playful ice cream eating experiences together with sound as part of a social activity.

The focus of the second group discussion session was on designing a sound system for eating together. The idea was to build a sound system that can support two interdependent ice cream cones at the same time. Two sound designers helped me in creating a possible sound system. For the first iteration, the discussion focused on three possible sound-composing patterns that included composing two single notes with consonance and composing a major pentatonic musical scale with different instruments and overlapping composed sounds created by professional composers followed by a synesthetic approach (Merter, 2017). The last group discussion session focused on envisioning and evaluating potential interactions based on the PLEX cards (Lucero et al., 2014), for example, what forms of play can be facilitated by eating together.

5.3.2 Designing the sound system for eating together

I started by exploring the literature and took into account findings from earlier studies (Ishii, 2004; Vandevelde et al., 2014; Wu and Bryan-Kinns, 2017). As each biting or licking ice cream action is usually around 0.5 to 0.9 seconds long, the consumption of a regular 1-scoop ice cream portion is about 5 to 10 minutes on average (Wang et al., 2019). To design a playful social experience, the main challenge for the sound design of the system was that each player's sound should work musically with the other's. As a result, I decided that the generated sounds should be a short musical phrase. I first set up two distinct instruments with a single note in Ableton Live for each cone (grand piano and wind instrument) to have strongly differentiable sounds. Then, I observed people's initial experiences in a pilot study. I found that players could play a melody on top of each other based on a similar eating speed, while the sound seemed to turn into chaos if the eating speeds were very different. Nevertheless, I was encouraged to find that even generating a simple note through eating ice cream appeared to make the overall eating experience more engaging than eating ice cream in the regular way. The simplicity of a single note appeared to cause people stay engaged. However, I acknowledge that this could be because the participants were using the system for the first time. My intention was also to support repeated engagement with the system. I therefore attempted to work with richer sound elements. I mapped the normalised capacitance data to a major pentatonic musical scale to generate continuous sounds rather than a discrete sound (Figure 5.4). When the player performs a licking-on and licking-off actions, the system triggers different notes along a major pentatonic musical scale. Inspired by a piano-based gameplay (Micheloni et al., 2019), I also set up a chord effect in one of the sound patches to support a collaborative way of playing. As result, the overall melody was like a piece of high-pitched, consonant and legato sound. WeScream! offers open-ended game play. Players can freely perform any eating actions and explore how to play music or create a steady flow of sounds through eating ice cream together.

5.3.3 Pilot study

The final stage of the design process was to conduct a pilot study with users to confirm the sound system and to make sure that the technical aspects of the WeScream! system were working as intended for the in-the-wild study (Rogers, 2011). I invited three pairs to participate in a series of trials, each lasting 30 minutes including playing WeScream! with the sound system and a short exit interview. Participants could freely perform any eating action. I noted their facial expressions and eating actions. I acknowledge that ice cream is a calorie-laden food and its consumption could cause weight gain (Burger and Stice, 2012). In my study, I suggested players limit themselves to one scoop each time while eating ice cream together (Figure 5.5). The participants were free to refill the ice cream during the study. I observed that participants clearly understood my intention with the cone: "I like the feel of this cone, it looks like a real waffle cone." I also noticed how WeScream! enriched their enjoyment: "It is cool. We can produce sounds together by eating ice cream together." In terms of the design of two sound systems, participants commented: "The musical scale one is more interesting than the single note because it

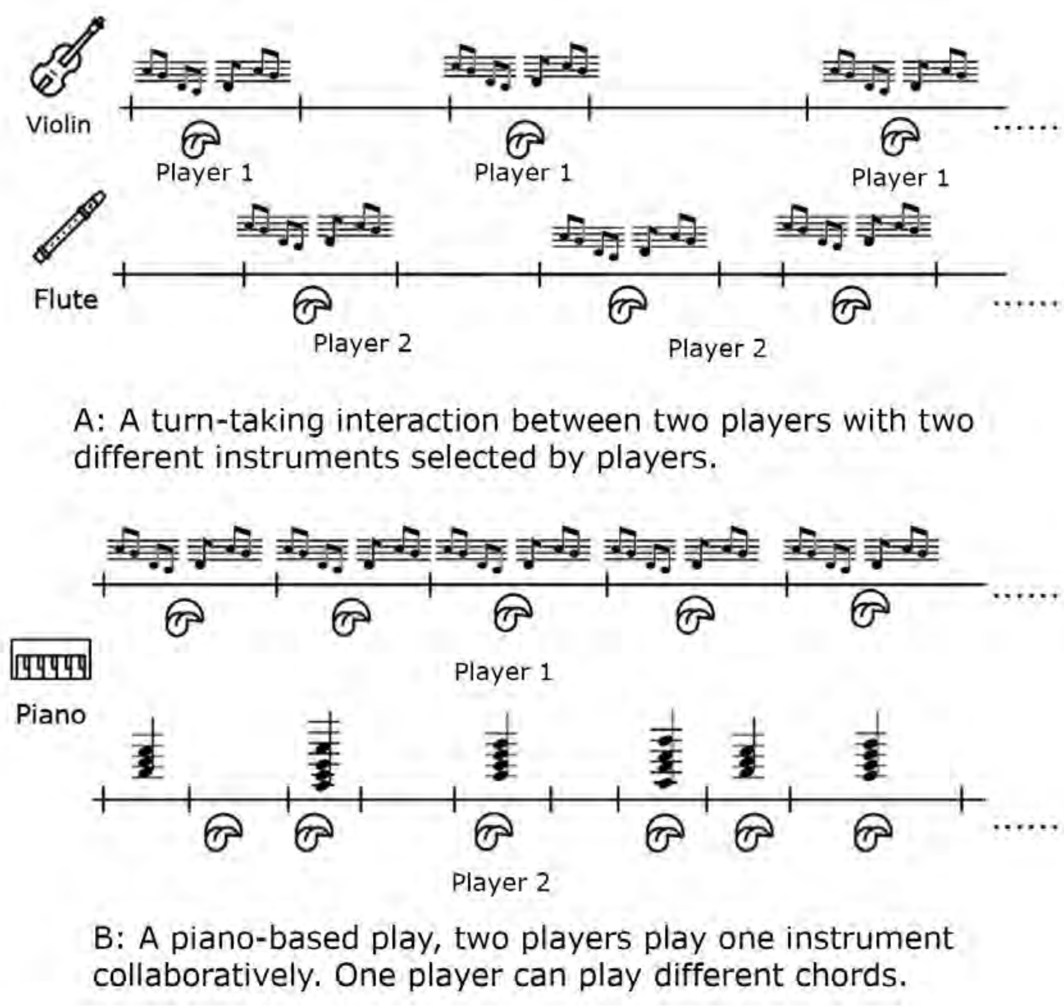

Figure 5.4: A set of example interactions with WeScream!.

produces continuous sounds via licking once." I also noted that participants were able to improvise music based on some rules, for example, "We decided the eating order and tried to keep the same pace of eating. It added more tension during eating."

Figure 5.5: Players had a great time experiencing WeScream! talking and laughing.

5.4 WeScream! in action

I conducted an in-the-wild study (Rogers, 2011) with 5 pairs (3 males and 7 females in total, age 26±1.8 (mean±S.D.) years) to investigate their experiences with WeScream!. The players in each pair knew each other before the study. I told participants that they could use the system anytime they wanted for one week. Table 5.1 provides the demographic details of each pair along with their relationship and cultural backgrounds. All participants had lived in Australia for more than one year. The participants were all studied in the same city. The cultural backgrounds of the participants are based on the places where they grew up (Global, 2021). Four participants were fond of ice cream, while the others were neutral. Nine participants were non-musicians and one participant had musical training.

TABLE 5.1: Participants' details along with their relationship and cultural backgrounds. (pseudonyms used).

Household	Name	Relationship	Cultural background
H1	Evian (M, 30)	Partners	Chinese
	Suki (F, 25)		Chinese
H2	Amber (F, 24)	Roommates	Australian
	Emma (F, 25)		Australian
H3	Ben (M, 27)	Partners	Australian
	Hanna (F, 26)		Chinese
H4	Skyla (F, 25)	Roommates	Singaporean
	Rina (F, 23)		Chinese
H5	Richard (M, 27)	Partners	Chinese
	Zoey (F, 25)		Chinese

I first conducted a pre-study interview where I checked whether participants were allergic to ice cream. Each pair received a kit containing two 3D-printed cones, one Wi-Fi router, several pieces of food-safe aluminum foil, and a MacBook Pro running the sound software to take home. To mimic real eating experiences, I suggested that users put an off-the-shelf plain waffle cup into the cone before placing ice cream into the device. Participants were given AUD20 to buy off-the-shelf ice cream of their choice for the study. I also provided sanitiser wipes and napkins to clean the cones and any spilled ice cream (Figure 5.6). No other financial compensation was provided. I spent around 30 minutes explaining the study procedure and performed a demonstration of how to use the system.

I also provided each participant with written instructions on how to set up the system and how to clean the cones after using it. I expected the setup and cleaning phases to take less than three minutes. I maintained contact with participants through emails and phone calls in case they needed any technical support. I asked the participants to engage with WeScream! a minimum of five times in one week simultaneously with their partner. I also suggested that players limit themselves to one scoop each time when eating ice cream together. On average, participants used the system once a day, most often after mealtimes, for approximately 10 minutes (actual eating phase).

FIGURE 5.6: Each pair of participants received a kit containing the WeScream! system.

Participant performed the following tasks while using WeScream!:

- **Setup phase.** Participants switched on the cone before using it, put a piece of food-safe aluminium foil and a plain waffle cone on the top of the device, then placed one scoop of ice cream on the top of the plain waffle cone. Figure 5.7 shows the three-step setup phase.

Figure 5.7: The preparation process: (a) disinfected cone; (b) placing the aluminum foil; (c) serving the ice cream.

- **Use phase.** Participants began by clicking a button to reset the sensing data in the Pure Data program and chose their preferred instrument in Ableton Live. The participants then ate ice cream. The program generated a piece of a melody while participants ate ice cream collaboratively.
- **Cleaning phase.** Participants disposed of the piece of aluminium foil, as it was for one-time use, and disinfected the disconnected parts of the cone with the sanitiser wipes.

5.5 Data collection

The main source of data was the interview conducted at the end of the study, which went for about 30 to 45 minutes. I interviewed each pair together at the same time. I used a semi-structured interview approach to leave sufficient room for topics so as to support deeper elucidation of participants' responses and thinking processes. During each interview, I took notes and audio-recorded interviews which were later transcribed for future analysis. I listed questions related to the research aim to remain on track while leaving sufficient flexibility for discussion. The questions revolved around their motivations, expectations and experiences of using WeScream! such as: when they used the system, what kinds of instrument they picked and how this affected the experience, as well as observations or insights they had regarding their own or their partner's eating behaviours and any interesting stories that came out of using WeScream! together. I also gathered feedback on the system's design, collaborative interactions and usage scenarios. Additionally, I welcomed opportunities to view any photographs and recordings of their interactions with WeScream! that participants captured during the study; this additional data helped me to investigate how users reacted to and integrated WeScream! into their everyday life.

5.6 Data analysis

I utilised inductive thematic analysis (Braun et al., 2008) to analyse the collected data. The semi-structured interviews were transcribed using NVivo (NVivo, 2021). Each question and its answer by each pair of participants were put together and considered one unit of data. In total, there were 382 units of data included in the analysis. I read all units several times to create code labels. These codes helped to identify the most interesting features of the data unit in order to group them together afterwards. In the first-round iteration of the thematic analysis I developed 40 labels, for example, "Understanding the device", "Real-time sounds", "Collaboration" and "Eating actions". In the second round, I re-examined the 40 labels to merge similar codes into broader labels to reduce the complexity. The remaining codes were refined and merged into previous labels with the help of two senior researchers. Finally, I decreased the number of codes to 13. The analysis resulted in three themes that unpack the overall experience: playful social gustosonic experiences supported coordinated eating actions; improvised sounds facilitated shared attention to food; and awareness of relatedness increased through experiencing WeScream!.

5.7 Findings

The analysis resulted in three themes that detail how the playful social gustosonic experience supported coordinated eating actions and improvised sounds facilitated shared attention to food and increased awareness of relatedness. I use these themes to articulate three design tactics for designers aiming to create playful social gustosonic experiences.

5.7.1 Theme 1: Playful social gustosonic experiences supported coordinated eating actions

This theme describes how playing with ice cream through sounds supported coordinated eating action. Consuming ice cream in different ways became a reward to support challenges, competition and collaboration, and variations of sound facilitated coordinated eating actions.

F1: WeScream! offered challenging yet enjoyable experiences.
Participants told me they enjoyed the fact that playing sounds and eating ice cream were not separate but connected. Participants also appreciated the distinct sounds from the two cones, allowing them to explore variations of sound through eating together such as timbre, intensity and rhythm. Although they struggled to control the sounds well at

the beginning, they discussed their experience and came up with a set of eating rules to create more pleasing compositions. Ben said: “She [Hanna] suggested we should eat slower with small portions of ice cream each time, then we can create a stable piece of melody.” All participants liked how eating ice cream allowed them to create sounds together. However, they also said that collaborative interaction with sounds through eating ice cream was difficult. Six participants found it challenging that they could not collaborate as well as they wanted to with their friends or partners. For example, Amber said: “I think I need to practise my eating skills to produce a good melody. I was hoping that I could interact with the ice cream through my hands, like playing a guitar.” Rina thought that adding an LED light as a metronome could help them produce a piece of highly rhythmic music. She said: “If there is a light in the cone as a metronome, that would be great, we can perform a better rhythmic melody.”

F2: WeScream! supported coordinated eating actions through multiple strategies.

Although controlling sounds well was difficult for most participants the first time, WeScream! offered an enjoyable experience when the participants overcame the difficulty. For example, Emma said: “Eating with another person and playing some sounds together was fun. This thing I haven’t experienced before.” The success of collaboration depended on the proper synchronisation of eating between the two players; as Emma explained: “In the beginning, it was frustrating to play some noise. We stopped and gazed [at] each other. I feel like we got the same ideas without any talk, then we were biting ice cream at the same time.” Amber also agreed that the playing of sounds collaboratively depended on effective communication. She said: “Eating was like playing a game, but with more fun. We also got to think about strategies, like who will be the first eater and then who will play the main sounds”. Ben and Hanna said that they tried different eating actions, such as changing their eating pace, extending their licking time and consuming larger portions of ice cream. Ben reported that he figured out how his eating pattern could generate a similar melody to what he was able to achieve before. Hanna added: “We figured out how to create legato melodies through eating with this [WeScream!]. For example, I can ‘quick lick’ two times and not release for 3 to 5 seconds, then he [Ben] should lick small portions of ice cream and lick slightly”.

F3: Participants enjoyed a slow eating pace through competition.

The WeScream! system drove an eating competition for three pairs of participants. Richard and Zoey competed with each other in terms of who would generate a more listenable melody through licking or biting actions. Richard said: “We found that eating pace should be very slow, to control the sounds better. On Saturday afternoon, we started with her first and she generated a piece of soft and legato melody with a grand piano instrument. Then I tried to eat slower than her to add some chords on the top of each other. We came to appreciate playing intricate and listenable music together through eating ice cream. It was a wonderful moment. So we started laughing." Zoey added: "It was like a competition but to compete who was the slowest."

F4: Participants modified sound sources to increase enjoyment.
Participants enjoyed generating new sounds with different instruments and eating different kinds of ice cream as part of that. Evian said: "I am looking forward to playing something new each time. I feel sometimes we are playing an instrument together and sometimes we are like a band. We tried to create similar sounds like yesterday, but we cannot do that again." Suki added: "If I had plain ice cream as usual, I would already know nothing will come through. It was exciting to try different instruments everyday while eating ice cream". Richard and Zoey also reported that they were able to correlate sounds that they generated the previous day, which in turn encouraged them to try to create new sounds through adding sounds effects to the system.

5.7.2 Theme 2: Improvised sounds facilitate shared attention to food

This theme depicts how improvised sounds facilitated shared attention to food.

F5: WeScream! prompted attention to each other's eating behaviours.
Players reported that WeScream! made them pay more attention to each other's eating behaviours. For example, Suki said: "It was interesting to notice his [Evian] eating behaviours during playing. When I have dinner with friends, I never noticed others' eating behaviours, because we are in a conversation." Building on this, Richard said: "It made me think about how I was eating ice cream with my friends and how they thought about my eating actions. I usually eat food fast but when we eat ice cream together with sounds, I have to slow down to collaborate with my partner." In particular, participants' eating behaviours were influenced by their sound collaboration. For example, five participants said that they paid attention to their eating speed. They found that if they kept their eating speed as usual, they could not get a "listenable" melody. To better collaborate with their friends or partners, they therefore ate the ice cream more slowly. Evian said: "It was challenging to slow the eating pace at first, but I decided to cooperate with my partner [Suki] to have fun together rather than finishing an ice cream." Ben also said: "I did not know how fast I eat ice cream before this study as well as how slowly my partner [Hanna] eats. But we tried to synchronise our eating pace and licking actions, creating rhythmical sounds during playing."

F6: Ambiguity of sounds led to focus on food.
Six participants reported that a delay in the sound as a result of technical problems with the feedback added a welcome surprise. The WeScream! system sends sensed data from

the ice cream via Wi-Fi to a laptop, then outputs the sounds through two Bluetooth speakers simultaneously. These two signals might influence each other sometimes. This situation was perceived as a surprise, which added ambiguity to the experience. This was not negatively judged by the participants, but, rather, they described it as a space for reflection on the relationship between their eating actions and the ice cream. As a result, it appears this ambiguity brought participants' attention back to their food. For example, Suki said: "Given the system was suddenly mute, I paid more attention to my ice cream." Similarly, Zoey said: "When it suddenly stopped, it was like a surprise, and we intuitively began to eat again, even touched the ice cream with fingers." Richard added: "The ambiguity of the mute time is an interesting thing. It made me think about our eating behaviours, and we gazed at each other's ice cream."

F7: WeScream! facilitated reminiscing about past social experiences.
Engaging with WeScream! appeared to facilitate participants reminiscing about their past social eating experiences. Participants said that the experience reminded them of the times when they enjoyed ice cream with friends, talking about their previous ice cream eating experiences. For example, Evian said: "The experience reminded me of gathering with my best friend to eat ice cream together in a wonderful restaurant when she went to a university last year." Similarly, Skyla said: "I enjoyed the experience a lot, especially the bit where we were playing sounds through eating together, as it reminded me of a classical digital drum game called Rock Fever when I played it a lot with my friends in my grade nine."

5.7.3 Theme 3: Awareness of relatedness increased through experiencing WeScream! as an everyday source of happiness

This theme describes how WeScream! was not just about eating a novelty ice cream but was a pleasurable experience towards an everyday source of shared happiness.

F8: Preparing WeScream! brought participants together.
Four participants reported how preparing the ice cream brought them together. Amber said: "We started with plain vanilla-flavoured ice cream because we thought this was a study. But after creating [a] listenable melody together, we enjoyed having ice cream together. Emma and I thought we could go shopping together to order different flavours of ice cream as rewards for the next time." Participants also chose each other's favourite ice cream as a gift. Suki said: "Since we found our ways to play continuous music together, we felt 'success!' And when I found he [Evian] brought a box of mocha-flavoured ice cream for playing next time, I felt happy and grateful and [was] looking forward to playing again."

F9: WeScream! increased face-to-face communication.

WeScream! appeared to increase face-to-face communication while eating ice cream together. Four participants described explicitly that they usually sat on the couch and watched TV or played video games while eating ice cream together, at home. They said how there was rarely eye contact during eating, and the talking was mostly brief, with only a couple of words, since their attention was on the TV. However, they said that WeScream! brought their attention back to face-to-face communication. All participants reported how they enjoyed this as a result of discussing how to play sounds together and how to eat the ice cream. For example, Amber commented: “It got us talking more, in particular, face-to-face communication with each other. Although we are sharing a house, we have little conversation during mealtime in our house. We even send messages via social media to chat with each other when staying in the same house.” Emma added: “We discussed strategies face to face and reminded each other about each other’s eating order through eye contact.”

F10: WeScream! was used for comfort and emotional support.

Interestingly, WeScream! motived participants to gift ice cream to their partner. Zoey told me: “One day, I felt my partner was unhappy when he was back home. He said that his best friend would move abroad soon, which he felt a bit down about. I felt I could surprise him to help him reduce the bad mood. I set up the system [WeScream!] and picked up a bell instruments that sounded like giggling.” Richard was laughing and added: “That was a big surprise. She fed me ice cream, then some sounds suddenly came out. We were laughing together, and I felt better at that moment.”

F11: WeScream! fostered intimacy in partnership.

Although participants knew each other before the study, six participants described that playing with sounds through eating with their partners fostered intimacy. Ben narrated a scenario to us: “Sharing one ice cream with friends is a bit weird. However, we [Ben and Hanna] were spontaneously feeding each other with our ice cream during the study.” Hanna added: “We also crossed our right arms with each other to eat ice cream with sounds collaboratively.”

F12: WeScream! facilitated reflection on social bonding.

Two participants sent messages to me after the end of the study. Before the study, Skyla and Rina knew each other for two weeks as Rina was Skyla’s new roommate. Skyla said: “We miss the ice cream cone, it was a good icebreaker. We remembered the enjoyable eating experience with each other and how we collaborated with playing the sound through eating. Now we cook together and share meals every day at home.” For example, Rina added: “It was more fun to generate sounds collaboratively, as it involves more connections with the other person when eating together.” Participants believed that eating with sounds could act as an icebreaker between strangers in a public place because it pushed people to interact with each other. Rina said: “I am thinking of this as a good way of interacting with others when eating alone in a food court on campus.”

5.8 Design tactics

Together with my craft knowledge gained from designing WeScream!, I present three design tactics relating to the findings. I hope these design tactics can provide designers with practical guidance when aiming to create social playful gustosonic experiences.

5.8.1 Tactic 1: Support playing with sound rather than composing music to facilitate playful social gustosonic experiences

The study indicated that the ability to play with sounds can be an important factor in a coordinated eating interaction and relates to overall playful experiences. In order to facilitate collaborative interaction, this approach allows each player to control a musical scale through licking-on and licking-off actions. My initial intention with WeScream! was to support players to compose rhythmic music. For example, the licking-on and licking-off actions would add a number of drum sounds on top of a background sound. However, due to the ephemeral nature of ice cream, as it changes its volume and texture with every bite which results in different sensing signals, I noticed that it became quite difficult to collaboratively compose music as it required eating very precisely. Prior work already highlighted that precision is an essential feature in composing rhythmic music in real time (Robson, 2002). To solve this problem, I changed the initial design of WeScream! to instead use one single note with a C major scale and a looped note repeating over time. The result was that the system offered an interesting way to play with sounds collaboratively, yet the interaction remained simple. However, participants from the pilot study reported that the collaborative interaction offered very few surprises, resulting in the outcome becoming monotonous. To address this, I altered the design again and this time mapped the normalised capacitance data to a major pentatonic musical scale with different instruments and added a chord effect in one of the sound patches to enrich social play around sounds. The study suggests that this approach was successful, with participants describing their activities as playing with sounds, rather than composing music.

As such, I recommend that designers could consider supporting playing with simple sounds with different timbres, rather than to composing music, to facilitate playful social gustosonic experiences. In particular, I highlight that designers should think about using basic sound parameters and the control of global sound quality such as volume and pitch. Employing such an approach has the additional advantage that the basic sound palette can be easily exchanged to suit different contexts; for example, some participants might like more bass and synthesiser sounds for a more electrical music-type experience.

5.8.2 Tactic 2: Utilise ambiguity as a design resource to support savouring

Ambiguity is usually considered an undesirable quality in the field of HCI. However, Gaver et al. (2003) argued that ambiguity could be a resource for design to encourage close personal engagements with an experience. Prior work has suggested that adding an incongruous quality to an original experience could be useful in spurring people towards a particular experience (Gaver et al., 2003; Velasco et al., 2016). There were several aspects of ambiguity revealed through my study. In this study, I offered participants a "naturalistic" ice cream eating experience that integrates well with sensing technology. To design playful eating experiences and technologies, Wilde and Bertran (2019) argued that technologies should support the actual eating activity, rather than disrupting it. WeScream! stepped towards crafting ice cream eating experiences by employing embodiment in the field of multisensory perception. A 3D-printed ice cream cone was crafted with a light wood filament to mimic the look and feel of a regular ice cream waffle cone. Then, adding sounds as an incongruous quality of a naturalistic ice cream eating experience created ambiguity for participants. Participants liked the tactile experience of the 3D-printed cone because it felt like a real waffle cone. This ambiguity of relationship caused participants to pay attention to the ice cream during eating and facilitated a free-form exploration (Arrasvuori et al., 2011). Participants also reported that they became aware of a delay glitch during playing with WeScream!, but they did not know the exact cause. This imprecise sound feedback also allowed participants to reflect on each other's eating behaviours and shared attention to each other's food. The incongruous and imprecise features of the WeScream! system allowed people to experience savouring. Savouring refers to the focus of attention on the sensory input of consumption experiences (Cheung and Hanh, 2010), highlighting a "heightened awareness" that makes people "more fully conscious of the pleasurable things we see, hear, smell, touch, or taste". With WeScream! participants became aware of changing sounds through eating ice cream together and while they started paying attention to each other's eating behaviours, they appreciated playful social eating moments despite enduring struggles in controlling sounds.

Therefore, I suggest that designers could consider ambiguity as a design resource to support savouring around social eating scenarios. Moreover, this work indicates that ephemeral characteristics of an edible interface (Kwon et al., 2015) might be an ambiguous design resource to facilitate reflections on savouring.

5.8.3 Tactic 3: Design playful social gustosonic experiences as "hard fun"

This study identified that playful social gustosonic experiences were not just about eating a novelty ice cream together. It appeared to also become a "hard fun" experience towards a playful engagement with social eating experiences. Hard fun is defined by Lazzaro (2009) as the "rewarding process of mastering a challenge that involves the creating and testing of strategies and the application of effort." The key to the enjoyment of "hard fun" is generating strategies and applying creativity and the development of skills. In this study, I found that participants enjoyed the challenge of creating sounds through coordinated eating. They relished putting in effort to pursue the sense of completing a piece of melody together. Participants could experience play actively through eating ice cream together. They quickly realised that their awareness of their differences in terms of eating behaviour were a valuable asset to enrich the sound-making experience. They then came up with strategies and tested them out to get more pleasure. For example, participants discussed how to create a particular piece of music by having the more skilled player (the one whose eating speed was slower) trigger the main rhythmic chords for both players. Another example is where players discussed that they would try to lick as slowly as they could to generate a better melody than the other's, turning it into a competition. They also enjoyed the process of exploring how much better they could play with sounds through slowly licking with each repetition. The findings also suggest that players often started the experience by engaging in similar, synchronous eating actions as a way to collaborate with their partner. As such, participants explored strategies for being dependent on one another through their eating actions, challenging participants' normal eating behaviours as a way to facilitate playful social eating experiences. Prior work already suggested that designing interdependence in cooperative play may enhance players' perceptions of connectedness and social engagement (Harris and Hancock, 2019). With WeScream!, when participants encountered failed cooperation, the negative experience also increased focus and concentration on the ice cream and potentially enhanced eating behaviours through coordinated eating interactions.

Overall, I suggest that designers could consider designing interdependent and open-end gameplay to create competition or cooperation as hard fun supporting playful social eating experiences.

5.9 Conclusion

In this case study, I have presented WeScream!, which allows users to interact with rhythmic sounds generated through the act of eating ice cream together. WeScream! offers open-ended gameplay where players can freely perform any eating actions and shows how to play music or create a steady flow of sounds through eating ice cream together. A qualitative analysis of an in-the-wild study with five pairs of participants has allowed me to derive three themes and three design tactics to analyze and design playful social gustosonic experiences.

The second case study showed that a playful gustosonic system can facilitate positive social eating interactions to enrich social eating experiences. This study extended my understanding of how to design social gustosonic play for eating together and how to design playfulness in social eating activities. This work also highlighted the potential for playful gustosonic experiences with ice cream to facilitate an in-the-moment playful eating experience. However, ice cream is considered a pleasurable treat when consumed in moderation and is usually eaten only occasionally, so ice cream may fall short in helping me with my understanding of how to design playful gustosonic experiences, as some of these gustosonic experiences might not be "special occasions" but are, rather, concerned with frequently repeated everyday eating and drinking activities. As such, my next step was to design a playful beverage-based gustosonic system in order to understand how the design needs to change if it is concerned with frequent everyday eating (and drinking) experiences.

In the next chapter, I will present "Sonic Straws", which allows players to experience playful personalised sounds via drinking beverages through straws.

Chapter 6

Case Study 3: Sonic Straws

6.1 Introduction

THIS chapter describes my last case study,"Sonic Straws", a playful beverage-based gustosonic system in the form of an augmented cup that allows users to experience playful personalised sounds via drinking beverages through straws. With Sonic Straws (Figure 6.1), players can use personalised sound clips to generate melodies through two straws at the same time.

My two previous studies demonstrate that playing with sounds while eating ice cream can contribute to the playful and social character of the experience. The results showed that digitally generated sounds can affect in-the-moment eating experiences via eating ice cream individually or with others. However, ice cream is frequently cited as an example of "mood food" (Spence, 2017a; Spence et al., 2019b) and is generally considered a pleasurable treat when consumed in moderation (Linley et al., 2013). Compared to consuming ice cream, people consume beverages, especially water, more frequently in everyday life. The WHO (Barzilay et al., 1999) states that an adequate daily water intake is about 2.2-2.4 litres (about 9-12 glasses of water) for adults in average conditions. This means drinking activities are pervasive and play a crucial role in people's daily routines. Inspired by the findings from case study 1 and case study 2 that suggest players could find value in enjoying pleasure via a playful gustosonic experience with ice cream, I extended these prior works by expanding my understanding of how to enrich such experiences when they go beyond one drinking/eating treat. This could lead to enriched drinking experiences and facilitate pervasive play in everyday life, promoting entertainment, sociality and reflection, and could potentially even be used to guide the

FIGURE 6.1: The participants can enjoy the Sonic Straws system anywhere and anytime.

design of future systems that aim to help people to drink water more proactively and frequently through play, ultimately benefiting people's physical and mental wellbeing.

To understand the UX of Sonic Straws, I conducted an in-the-wild (Rogers, 2011) study with 8 participants using the system for a week each. The study resulted in an enhanced understanding of the UX with Sonic Straws, especially how a playful gustosonic system can facilitate pleasurable drinking experiences in everyday life, going beyond one particular eating/drinking episode as was the focus in prior work.

In this case study with Sonic Straws, I answer my primary research question by investigating the sub-research question: *How do we design playful gustosonic experiences with beverages to support playful everyday drinking activities?*

6.2 Sonic Straws

Sonic Straws (Figure 6.2) is a playful beverage-based gustosonic system. The Sonic Straws system dynamically generates playful digital sounds when the user drinks any beverage through one, the other or both straws. The design also allows users to play their own personalised sound clips. The system consists of a customised lid and a holder containing a microcontroller (Adafruit Circuit Playground Express (CPX)), an amplifier and a 3.7 V lithium battery attached to the bottom of a regular (food-safe) cup. I chose to use a CPX for its capacitance-sensing capabilities, onboard speaker and handling of

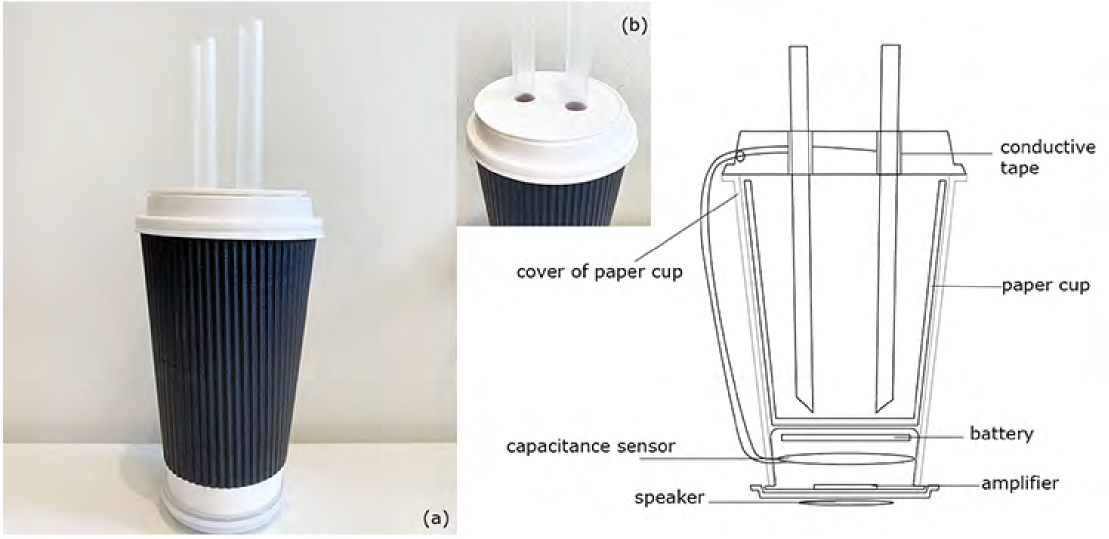

Figure 6.2: Sonic Straws system configuration: (a) Sonic Straws consists of a paper cup, a customised lid and a holder; (b) the customised lid with two holes includes removable copper conductive tape for sensing via the straws.

sounds-files replacement. To play sounds at high quality, I added an amplifier to the CPX. Sonic Straws is a portable stand-alone system. It senses capacitance data via the two straws connected to the microcontroller. The detected capacitance data is mapped in order to trigger sounds when the value goes above a threshold. The sensed capacitance value varies depending on the user's drinking action via the straws. To further enrich playful interactions, I used two straws that can sense drinking actions simultaneously while generating different sounds as a connected sequence. Therefore, the user can move their mouth between the two straws to create a continuous melody.

6.3 Design process

I developed Sonic Straws through an iterative design process that involved sketching, group discussion, and creation of several low-fidelity prototypes. Three group discussions were conducted to help refine the prototype and to gather diverse insights into how people drink in everyday life. The group discussion sessions included seven experts with diverse academic backgrounds: four interaction designers (from general HCI, with two of them also from HFI), one industry designer and two sound designers. The first session aimed to identify and observe the actions undertaken while drinking through straws and to decide on technical feasibility. In the group discussion, the motivations for people drinking beverages together in various settings were discussed to arrive at the possible design choices. I note that sometimes people like to share a beverage with others based on companionship. Therefore, an intriguing design space appeared to be designing straw-based interactions for drinking together.

The aim of the second group discussion session was to set up a sound system for drinking beverages in everyday life. The idea was to build a sound system that can play different personalised sounds at the same time. In addition, to prolong and enrich the user's engagement with Sonic Straws, the two sound designers helped us select possible preset sound samples based on a soundscape appraisal model (van den Bosch et al., 2017) and the PLEX framework (Lucero et al., 2013) for choosing sounds in terms of pleasantness, arousal, and playfulness. All group members discussed three possible sound interactions: using MIDI single notes with consonance inspired by playing instruments; using preset playful sound clips based on prior work (Wang et al., 2019); and using personalized everyday sound clips selected by users. The sound designers designed three possible sound systems in Max/MSP (Cycling '74, 2021) to demonstrate different sound interactions. We also did initial playtesting, where we mapped drinking actions to each sound system. We then discussed the pros and cons of each system, and identified an initial sound configuration. Considering the repetition of sipping actions, I finally set up a sound configuration after 20 trials with different paces of drinking action during this prototyping stage.

The third group discussion session focused on designing a straw-based interface to support sustainability and ease of use. I aimed to support common forms for both the cup and the straws (e.g. size, weight, shape) to ensure their ecological and social validity. In the group discussion, all members discussed different solutions to support ease of use on sticky notes. We categorised the sticky notes and narrowed down a solution. Finally, I decided to conduct a pilot study for the intended in-the-wild (Rogers, 2011) study.

6.3.1 Designing a sound system for connected gustosonic experiences

The main challenge for the sound design was that the system should provide users with sustained playful engagement, as drinking is a pervasive and repeated activity throughout every day. I identified that each sipping action with a straw usually lasts 2 to 4 seconds. I therefore limited each sound clip to 3 seconds with a 1-second fade-out to allow players to react to what they heard during each sipping action. With Sonic Straws, I utilised playful sounds previously used (Wang et al., 2019) for the initial sound system. I found that even playing the same sound appeared to cause people to stay engaged with Sonic Straws in the pilot study. However, participants reported that after experiencing all the preset sounds, they were looking forward to richer sound feedback. I then decided that the sound system should support playing both preset sounds and personalised sounds selected by users in line with participants' preferences. I acknowledge that users might disengage with a novel system after the initial excitement vanishes (Gaver et al., 2006). This led me to design connected gustosonic interactions to facilitate a more

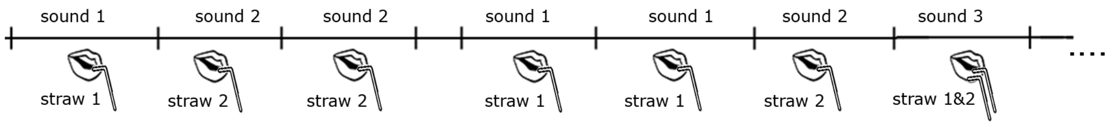

FIGURE 6.3: A connected sonic interaction between two straws with different sounds.

sustained engagement with the system. Inspired by musical instruments, I created two straws that can sense drinking actions simultaneously while generating different sounds as a connected sequence. As such, the user can move their mouth between the two straws to make a continuous melody. To further enrich playful interaction, I also set up additional sounds for when the user is drinking through the two straws together: during the design iterations, I found that the tempo of sounds also plays a key role in linking sounds together. Based on the pace of the sipping action, I first set up the rhythm of the sounds to be 80 beats per minute (BPM). I then found that users needed a faster pace to establish a perceived link between two sounds. After three more rounds of iteration, I decided on a rhythm of 110 BPM, allowing the user to perceive a transition between two sounds without losing context. As such, the user can create connected sound interactions individually or collectively (Figure 6.3).

6.3.2 Choosing preset sounds as guidance for gustosonic experiences

Previous work suggested that giving prior information about playful interactions can be useful in customising playful experiences (Ferrara, 2012). I therefore provided preset sounds (which users could change later) selected in consultation with the two sound designers from the group discussion sessions. The preset sounds were chosen to represent a broad range of sound designs. I chose four sound sets: anthropomorphism, fantasy, old school, and nature, respectively aimed to match the four main components of pleasantness in the soundscape appraisal model (van den Bosch et al., 2017): active, interested, enjoying and relaxed. Each set consisted of two sound clips for each straw. The set for anthropomorphism consisted of human vocal sounds that playfully responded to each other. Fantasy offered metaphorical sounds based on people's natural cognitive experiences (Back and Des, 1996), for example, a cat meowing and a bird singing. The set for old school consisted of short, legato and consonant sounds of classical instruments, for example, violin chords and cello chords. Finally, the nature set offered meditative sounds such as raindrops and forest sounds. I acknowledge that the understanding of these sounds is based on the user's cultural conditioning and natural cognitive experience mapping (Dubois et al., 2006); therefore, further exploration regarding sound content might be needed.

6.3.3 Implementing the final design

I adopted the experience prototyping design method, which enables users to gain first-hand experience by engaging with prototypes (Buchenau and Suri, 2000). Two researchers on this project used the Wizard of Oz technique (Dahlbäck et al., 1993) to play back the preset sounds using a normal coffee cup as a low-fidelity prototype in the first group discussion session. Based on the initial experience with the low-fidelity prototype, I then identified the following four design challenges for the final design of Sonic Straws:

- The design should prevent the electronics, including the battery, coming in contact with liquid.
- The form factor should resemble a standard sustainable cup.
- The cup should be easy to refill; moreover, users should be able to exchange the straws easily.
- All material in contact with the beverage should be food-safe.

For the implementation, I explored various forms of Sonic Straws. My initial idea was to place the microcontroller and speaker into a lid structure (Figure 6.4). However, during trials I found that this form evoked surprise and interfered with the sounds being heard. My second design was inspired by a regular smoothie cup. I embedded a replaceable cup inside a 3D-printed cup-shaped cover (Figure 6.5); however, I considered the size and weight of the second design to be too bulky and heavy, and it also caused a sensing issue while filling the cup.

Inspired by the "Affective Tumbler" (Suzuki et al., 2014), which consists of a holder containing a microcontroller attached to a paper cup for drinking beverages, I decided on individual components for my system. I designed a container for the electronics, complemented by a replaceable paper cup that sits on top of the holder secured with velcro and a customised lid with two holes including removable copper conductive tape for sensing via the straws (Figure 6.6).

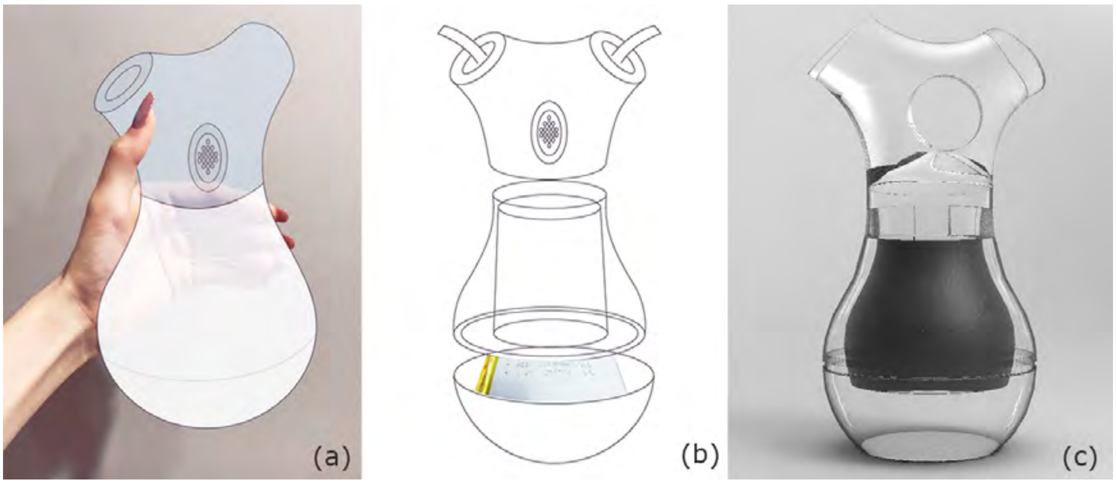

FIGURE 6.4: (a) The first concept design of Sonic Straws; (b) a microcontroller was placed into a bottom structure; (c) the appearance of the initial Sonic Straws.

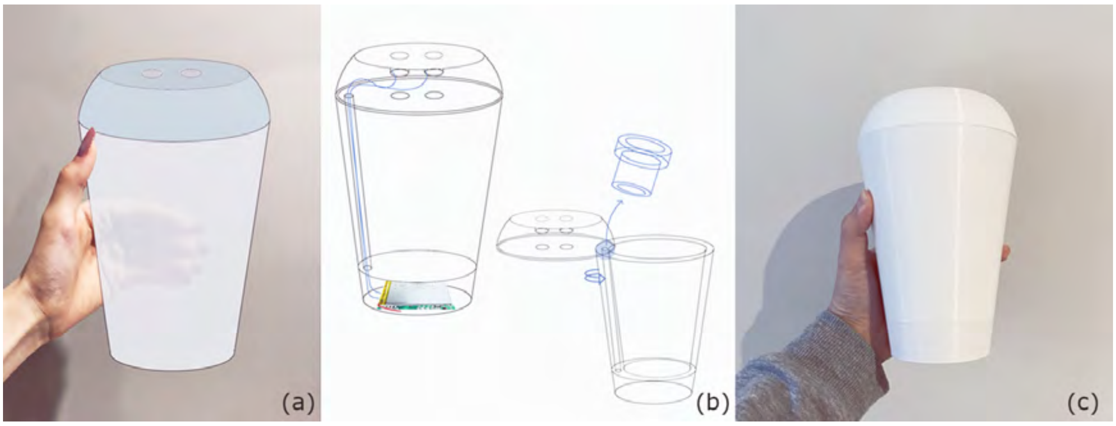

FIGURE 6.5: (a) The second concept design of Sonic Straws; (b) a replaceable cup was covered with a customized cover; (c) a 3D-printed Sonic Straws cup cover.

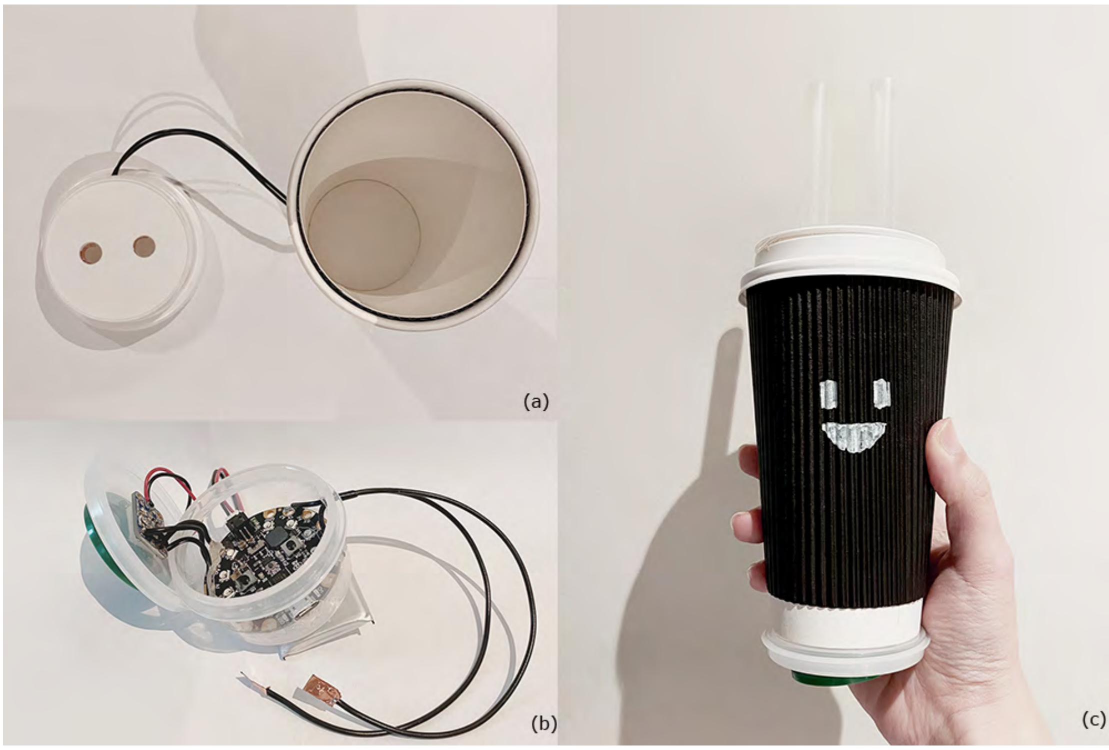

FIGURE 6.6: (a) A customised lid with two holes; (b) the electronics in the bottom container; (c) the Sonic Straws system with all components.

6.3.4 Pilot study

I conducted a pilot study to make sure that the technical aspects of the Sonic Straws system were working as intended for the in-the-wild (Rogers, 2011) study. I invited two participants to participate in a series of trials, each lasting 30 minutes, including an exit interview. I recorded how they set up the system and changed sounds, and their drinking actions. The participants were free to use the system any way they liked during the study. The participants seemed to understand my intention with the physical design-"I like this stand-alone device and it looks like a normal cup when I am drinking"- and enjoyed the personalisation option: "I have some funny sounds that I collected before. I can use these personalised sounds with this system. These sounds link my past memories, this is beautiful." In terms of the design with two straws, one of the participants commented: "It is quite interesting with two straws. I can use them at the same time individually and I also can share drinks with my partner." I also noted that participants were able to improvise music via interacting with two straws. For example, one of the participants said: "I chose bass drum and snare sound for each straw and a hi-hit [to] trigger both straws together. Then I found a sequence with [a] different pace of sipping action with two straws. It was like playing a drum while drinking beverages."

FIGURE 6.7: Participants in the same household experienced Sonic Straws in an indoor setting (left and middle photos taken by a friend at a party, selfies on the right taken by participants).

6.4 Sonic Straws in action

To understand the user experience, I conducted an in-the-wild study (Rogers, 2011) with 8 participants (4 males and 4 females in total, age 26±2.7 (mean±S.D.) years) to understand the UX with Sonic Straws (Figure 6.7). The study took place in four households with two participants in each. I decided to engage more than one person from the same household in order to understand the social dynamics regarding the use of Sonic Straws. I told participants that they could use the system any time they wanted, in any way they wanted, over a period of one week. No compensation was provided. Table 6.1 provides participants' details for each household along with their relationships and cultural backgrounds. All participants had lived in Australia for more than one year. The participants were all studied in the same city. The cultural backgrounds of the participants are based on the places where they grew up (Global, 2021). None of them reported problems with hearing or drinking disorders. None of them had musical training.

TABLE 6.1: Participants' details along with their relationship and cultural backgrounds. (pseudonyms used).

Household	Name	Relationship	Cultural background
H1	Keith (M, 23) Mark (M, 24)	Roommates	Chinese Thai
H2	Rina (F, 24) Aiko (F, 26)	Roommates	Chinese Chinese
H3	Jeannie (F, 26) Ethan (M, 32)	Partners	Chinese Australian
H4	Roger (M, 28) Zoe (F, 26)	Partners	Chinese Chinese

I provided off-the-shelf disposable cups, straws and lids. Although the system can support reusable materials, I opted for single-use components for hygiene reasons. Each pair received a package (Figure 6.8) containing a packet of straws, a packet of disposable paper cups with lids, two Sonic Straw containers with the electronics, an adhesive-backed conductive tape, two power banks and a MacBook Pro laptop for converting sound formats and storing sound data (all participants were comfortable with using laptops, including converting sound formats).

Figure 6.8: Each pair of participants received a kit containing two Sonic Straws systems.

After participants received the package, I spent around 30 minutes explaining the study procedure and performed a demonstration of how to use the system via videoconferencing. I also provided each participant with written instructions on how to set up the system and how to replace the cups and straws. I maintained contact with participants through emails and phone calls in case they needed technical support. I also asked the participants to engage with Sonic Straws at least once per day, either individually or with their partner.

Participants performed the following tasks while using Sonic Straws:

- **Setup phase.** After selecting personalised sound files, participants encoded them into the WAV format via Audacity (Audacity, 2021). I also supported the format conversion process by providing instructions and offered help, but participants did not report challenges in this regard. After conversion, participants connected the system to the laptop and uploaded their sounds. Then participants attached the conductive tape to the straws and the microcontroller (Figure 6.9).

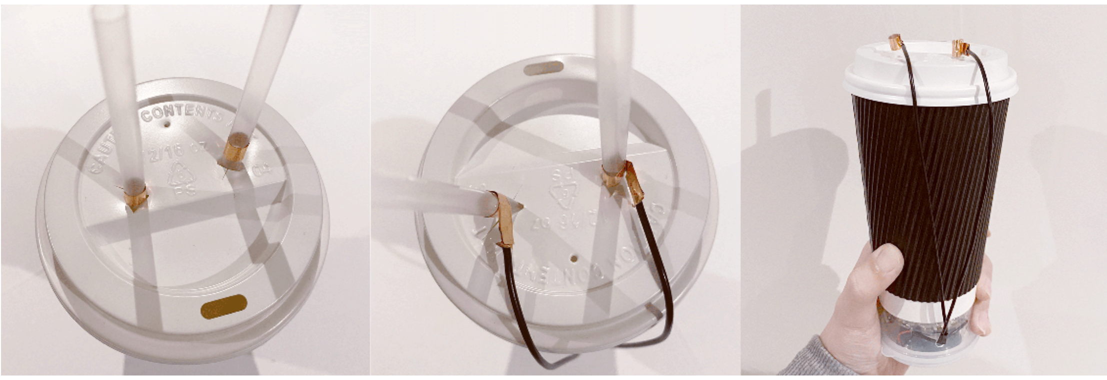

Figure 6.9: The setup phase of the Sonic Straws system.

- **Use phase.** Participants began by switching on the power and clicking a button on the microcontroller to start the system. Participants could also adjust the volume via a small knob we included in the system's container. Then participants were free to drink at any time, any way they liked, using any beverage. Participants were encouraged to log any information they thought might be relevant to the analysis of the experience, such as: what kinds of beverages they drank, what kinds of sounds they used, why they chose that sound set and how they felt at the time, as well as any reflections on using Sonic Straws.
- **Replacement phase.** Participants were free to dispose of the cup, lid and straws, and replace them as needed.

6.5 Data collection and analysis

The main source of data was the interviews conducted at the end of the study, which lasted about 30 to 45 minutes per pair of participants. I used a semi-structured interview approach to leave sufficient room for other topics in order to support deeper elucidation of participants' responses and thinking processes. During each interview, I took notes and recorded the audio, which was later transcribed. I asked questions related to the research aims to remain on track while leaving sufficient flexibility. The questions revolved around participants' motivations, expectations and experiences of using Sonic Straws, such as: when they used the system, what kinds of beverages they used, what types of sounds they used, and how the sound affected their drinking experiences, as well as observations or insights they had regarding their own or their partner's drinking experiences and any interesting stories that came out of using the Sonic Straws system. Additionally, I welcomed opportunities to view any photographs or recordings of their experiences with Sonic Straws that participants captured during the study; this additional data helped to understand how the users reacted to and integrated Sonic Straws into their everyday drinking activities. The interviews were transcribed using NVivo (NVivo, 2021) and I utilised an inductive thematic analysis (Braun et al., 2008) to analyse the data. Each question and its answer by each pair of participants were put together and considered one unit of data. In total, there were 332 units of data included in the analysis. Two of the researchers including me read the transcripts three times to become familiar with the data and then coded the data independently. These codes helped to identify the most interesting features of the data units in order to group them together. In the first-round iteration of the thematic analysis, 37 labels were developed, for example, "Understanding the device," "Harmonious melody," "Type of drinking," "Collective interactions," "Sensation of taste" and "Drinking actions". In the second round, two of the researchers discussed and re-examined the codes to merge similar ones into 22 labels to reduce complexity. These labels were then iteratively clustered into higher level themes with the help of two senior researchers in order to unpack the overall experiences.

6.6 Findings

I present my analysis of the interviews that resulted in the three themes: self-expression via playful drinking actions, pleasurable social drinking moments and reflection on participants' everyday drinking activity.

6.6.1 Theme 1: Self-expression via playful drinking actions

This theme depicts how participants: enjoyed aligning personalised sounds with the taste of the beverage; extended playful drinking experiences through personalised sounds; were rewarded with different sounds with each sip; engaged in self-expression through turning sipping into music-making; turned drinking into a form of sound's narrative potential; and enjoyed how the sounds could turn drinking into a relaxation opportunity.

F1: Participant enjoyed aligning personalised sounds with the taste of the beverage.
All participants appreciated that they could use their own sounds for self-expression. They aimed to select sounds that matched their emotions or past personal experiences and tried to align them with the taste of the beverage. For example, Aiko said: " I used sounds associated with my mood. And I would also think about the flavour of beverages for a few minutes before I used it. Then I would be focusing on whether the sound suited that flavor of beverage. Sometimes I drank milk bubble tea with a pleasant sound and I preferred to drink green tea with a forest sound." Moreover, Aiko reflected on her experiences during the study: "Sometimes I can hear background music or ambient noise while eating outside, but I do not pay attention to the content of these sounds. When it [Sonic Straws] generated sounds during drinking, I would get excited but also wondered, what is the next sound? Or what if there is no sound for the next sip?" Similarly, Rina said: "I enjoyed pleasant sounds when I used it; in particular I enjoyed bubbling sounds with sparkling water and soft drinks. "

F2: Participants extended playful drinking experiences through personalised sounds.
All participants felt that Sonic Straws was intriguing and exciting. For example, Jeannie emphasised how she was impressed by the sonic feature of Sonic Straws, especially in

comparison with typical experiences of drinking water: "I have a lot of cups, I bought them because of aesthetics or as a souvenir, but Sonic Straws stood out from other cups because of its playful and sonic features. I could design sounds for my favourite beverages." Similarly, Mark said: "This [Sonic Straws] is a new thing for me. It is interesting and lovely. I haven't seen this sort of thing before." Jeannie also designed her sounds according to the weather forecast while drinking tap water. She said: "When I used it over time [during the study], it made me think about other ways to design sounds. I often forgot to read the weather forecast, but I think that is important for daily routine. So I started by looking for the weather forecast in my location. I first selected sounds that could represent the weather for each day, like thunderstorm sounds, wind sounds and rainy sounds." Jeannie also described how she used Sonic Straws in particular ways: "Sometimes, I used one straw to represent daytime and the other for the night. If the weather suddenly changed, I would change the soundtracks. I also set up a sound that represented the weather for yesterday when I was drinking via two straws together. On the last day I used Sonic Straws, I reviewed all sounds on the laptop. It was fascinating to experience the sounds changing day by day while drinking."

F3: Participants were rewarded with different sounds with each sip.
Six participants described how they explore the four preset sounds sets by moving their mouth between the two straws. For example, Mark said: "When I drank with one straw the generated sound was slightly different from the second drink, then I moved my mouth to the other straw. Each sound was different. Later I quickly moved my mouth between two straws and the connection was interesting. It was like two animals could talk with each other. It provoked my imagination with a story while playing with two sounds." Aiko added: "I tried all the preset sounds with two straws, but when I drank with two straws together, the sound was totally different. It was like a reward for exploration."

F4: Participants engaged in self-expression through turning sipping into music-making.
Two households reported that the different sonic interaction possibilities allowed them to experience drinking as improvising music, which facilitated self-expression. For example, Keith said: "At first, I was excited to show my improvised sounds to my roommate. I tried different instrument sounds and various actions of drinking in order to present a piece of listenable melody. You know, the sound was like chaos at the beginning. After trials, I found my way to perform better. I moved my mouth between two straws and counted beats." Mark added: "Yeah, he did a really good job. You know, he is like a one-man band."

F5: Participants turned drinking into a form of sound's narrative potential. Two participants reported that they preferred to use human vocal sounds because these could turn into a story through drinking. For example, Mark said: "When you gave us this system, I tried all your preset sounds first. Those sounds were pleasant. But I found that I liked slow-paced human vocals so much [more with] the system. Later, I used similar vowel sounds and my favorite cartoon character's vocal sounds. It was like creatures were whispering to me while I was drinking!" Keith added: "I used two coherent vocal sounds for each straw. When I moved my mouth between the two straws, it sounded like echoes when you are shouting in the mountains."

F6: Participants enjoyed how the sounds could turn drinking into a relaxation opportunity.
Four participants felt hearing nature sounds increased their perception of being more relaxed while drinking. Jeannie compared her experience of drinking without sound: "Normally I drink beverages in a very relaxed situation or for releasing stress. With Sonic Straws, I mostly liked the forest sounds. Although the sound was episodic, this made drinking beverages more enjoyable." Zoe added: "I think drinking is relaxation and sounds like rainy sounds make me feel very relaxed. I liked the slow sounds; they made me enjoy drinking a lot and calm down."

6.6.2 Theme 2: Pleasurable social drinking moments

This theme depicts a further six findings on how participants' use of Sonic Straws influenced the way they drank beverages together: participants enjoyed coordinating drinking actions via playing with sound together; and inferred their partner's emotions based on sound selection; Sonic Straws's sounds facilitated social play over beverages; facilitated sharing beverages experiences; made participants curious about their partner's taste in beverages; and created opportunities for conversation.

F7: Participants enjoyed coordinating drinking actions via playing with sound together.
Sonic Straws appeared to facilitate coordinated drinking actions while participants played sounds together. Participants said that playing sounds with Sonic Straws together was challenging, yet enjoyable. To make a harmonious melody, the success of collaboration depended on the proper drinking actions, such as the drinking pace, release time and consumed volume of beverage with each sip. For example, Roger said: "We shared one cup of Coke while using it [Sonic Straws]. We found that coordinated actions were crucial for playing with shared beverages together. You could prevent one

person consuming a lot." Zoe laughed and added: "He sipped a lot each time. In the end the system only played his sounds." Interestingly, Keith and Mark said that they tried to use two Sonic Straws together for making music via drinking water. They found a drinking pattern for generating a melody. Keith said: "We figured out how to collaborate with each other to generate melodies with this [Sonic Straws]. For example, we chose instrument sounds from the system. I could sip one of my straws first and not release for five seconds, then he [Mark] could sip one straw twice and quickly move to the other straw for one sip."

F8: Participants inferred their partner's emotions based on sound selection.
Two participants reported that their partner's sound selection drew their attention to their partner's emotions. For example, Rina said that the sounds selected by Aiko drew her attention to Aiko's emotions: "I knew she selected sounds based on her mood. Those sounds made me realise how her mood changed. Sometimes the sounds were pleasant, like a bird sound or a cat sound. But I heard her favourite idol's voice a lot in one day. I think she was excited at that time." Similarly, Roger said: "Her [Zoe] selected sounds attracted my attention to her emotional state. I knew she preferred to use nature sounds while drinking water. When I heard different sounds one night, I asked her if there was anything making her happy."

F9: Sonic Straws's sounds facilitated social play over beverages.
Participants used the sounds to play games together, with some of them using the beverages as game rewards. For example, Keith said: "I was looking forward to hearing the sounds he [Mark] used every night. He used some cartoon characters' voices. It was cool. I could guess which character it was." Mark added: "It was like a puzzle game. We then talked around characters and related stories based on sounds." Similarly, Rina and Aiko designed a game with Sonic Straws before sharing beverages. Rina said: "I used Sonic Straws to share beverages with her [Aiko]. I only set up one straw to generate sound before sharing. Then I asked her to guess which straw should be used for creating sounds. If she chose right, she could drink first and consume more beverage."

F10: Sonic Straws's sounds facilitated sharing beverages experiences.
Six participants appreciated that Sonic Straws allowed them to share beverages while playing with sounds together. For example, Zoe said: "It [Sonic Straws] created opportunities for my partner [Roger] and me to interact with each other more. He used to spend most of his time on PlayStation or TV when we were staying in the living room. But when I used Sonic Straws, we didn't have to talk much, we would play with sounds together and share drinks." Similarly, Rina and Aiko reported: "We placed the Sonic Straws on our dining table. We enjoyed playing with sounds together and shared our favourite beverages after dinner."

F11: Sonic Straws's sounds made participants curious about their partner's taste in beverages.

Two participants pointed out that the sounds drew their attention to their partner's drinks. For example, Roger said that the drinking sound made him curious about his partner's taste in beverages simply through hearing the sound: "It's quite fascinating. The generated sounds also attracted my attention to what kind of beverage she drank. Those sounds made me feel that the beverage tasted special." Similarly, Ethan said: "The sounds attracted my attention to her [Jeannie's] drinking actions when she was drinking with that cup [Sonic Straws]. Then I asked her what kind of beverage she was drinking for fun."

F12: Sonic Straws's sounds created opportunities for conversation.

All participants appreciated that Sonic Straws sounds created opportunities for conversation. For example, Zoe said: "While Roger used it one night, I had a Skype call with my mum. My mum also paid attention to it [Sonic Straws] because of the sounds generated by drinking water. Then all of us started a conversation naturally around it." Participants mentioned that the sounds helped them to bring their attention back to the social aspects of dining together. For example, Aiko said: "When we ate together, we used to spend time on our phones. But when I drank water with it [Sonic Straws] at the dining table, the sounds could bring our attention back. Then we started a conversation naturally."

6.6.3 Theme 3: Reflections on participants' everyday drinking activity

This theme depicts the final six findings about how participants talked about Sonic Straws facilitating reflection in different ways. Participants had different interpretations while engaging with Sonic Straws in everyday life; Sonic Straws motivated participants to drink more frequently and proactively; Sonic Straws brought more awareness to everyday drinking activities; and facilitated reminiscence through personalised sounds; Sonic Straws's sounds where part of the gift-giving when making a drink for someone; inspired a desire for further personalisation; and led to reflections on voice-based smart agents at home.

F13: Sonic Straws motivated participants to drink more frequently and proactively.

Six participants reported that the playful gustosonic interactions motivated them to drink more frequently and proactively. They used the Sonic Straws system instead of their original cups for drinking during the study. Aiko said: "I used this cup [Sonic Straws] over time during the study. I drank more frequently than usual because of the sounds and I wondered how the sounds would sound differently each time while sipping beverages." Similarly, Zoe said: "I drank proactively with it when staying at home. It made me to enjoy drinking water by bringing in the aspect of sounds."

F14: Sonic Straws brought more awareness to everyday drinking activities. The Sonic Straws system brought participants more awareness of their everyday drinking activities. For most participants, the study was an effective ingredient in their daily routines while staying at home. Ethan described how the Sonic Straws system triggered a reflection on drinking interventions: "I know these sounds can not only be a playful resource but also affect the method of drinking in everyday life; for example, following a kind of musical rhythm, people can drink more slowly and stay mindful of getting hydrated." Similarly, Rina said that the system helped her to reflect on how she drank during the day: "Although this kind of experience is episodic, this [Sonic Straw] was more for fun, for mood. I liked undertaking this playful drinking activity because playing with sounds made me happy." Interestingly, participants mentioned how the Sonic Straws system became a part of daily life: "I found it was easy to use. When I was familiar with the sound system, I could use the drinking cup as usual while drinking water. When I wanted to have some fun while drinking, I would also easily turn it on or turn it off."

F15: Sonic Straws facilitated reminiscence through personalised sounds. Participants reported that engaging with Sonic Straws facilitated reminiscence regarding their past drinking experiences. For example, Jeannie said: "When I heard rainy sounds while drinking tea, it evoked my memories: because of a thunderstorm, we [she and Ethan] had to stay at a small tea shop and had afternoon tea there when we travelled to Kyoto two years ago." Ethan added: "Yeah, I could still remember the taste of oolong tea and the rainy sounds hitting the roof." By using sounds from her dog, Rina reported that the drinking actions supported her in reminiscing about her dog: "I think this [Sonic Straws] could be my companion. I used puppy sounds as I missed my puppy dog so much. It was like she was staying with me."

F16: Sonic Straws's sounds were part of the gift-giving when making a drink for someone.

Four participants performed the act of giving particular sounds to others. Rina narrated a scenario to us: "One day, I felt my roommate [Aiko] was frustrated. She told me she was struggling with her homework. She seemed a bit tired and down. That night, I secretly changed her sounds on the Sonic Straws. I felt I could give her a surprise." Aiko added: "It was so specific and a big surprise when I used it the next day. She used a cute cheering sound. It's kind of like she was telling me: 'You can do it!'. I felt much better at that moment." Similarly, Ethan told us: "I was a bit busy with my work at home. I had not tried the sounds as much as I wanted to, yet I enjoyed the sounds Jeannie selected for me. It was like a gift; you did not know when the sounds would be chang[ing].”

F17: Sonic Straws inspired a desire for further personalisation.
Interestingly, I found that Sonic Straws inspired a desire for further personalisation beyond the sound. For example, Rina drew some doodles on the outside of the cup that she believed matched the sounds she had selected: “I found that I could do more around the cup. I sketched two doodles on the surface of the cup when I heard those sounds. I used a cat meowing and a puppy barking, then I drew a kitty and a puppy to complete the story.” Aiko said: “I wanted to explore more of Sonic Straws rather than just playing with sound, so I played with those straws a little bit. I used different lengths of straw and designed a connected straw.”

F18: Sonic Straws led to reflection on smart voice-based agents at home.
Two participants reported that sensing errors with Sonic Straws promoted reflection on smart voice-based agents. In the system, the capacitance sensing can be influenced by strong electrical signals from devices such as a laptop, mobile phone or TV. Participants reported that resulting sensing errors added personality to the cup. This was not negatively judged by the participants but, rather, described as a space for reflection on smart voice-based agents at home. Zoe explained: “Once, I forgot to reset the system after I refilled the water one night. I put it near my laptop on the desk, then I went back to work. After a while, it [Sonic Straws] started ‘yelling’; that was surprising me. Then Roger walked through and looked at it, and then said: ‘Stop yelling, stop yelling’.” Roger laughed and added: “It was like a companion but also had its personality.”

6.7 Design tactics

Grounded in the user accounts and my critical reflection on my design choices, I now present three design tactics in relation to my results. These tactics could guide other designers when aiming to create future playful beverage-based gustosonic experiences.

6.7.1 Tactic 1: Utilise playful and personalized sounds to move players from drinking surprises to self-expression via drinking

The Sonic Straws’s sound system allowed the participants to use personalised sounds, which appeared to support their self-expression via playful drinking actions; this was greatly enjoyed. Prior work indicated that supporting personalization can facilitate self-expression and contribute to a positive experience with technology (Sung et al., 2009);

this seemed to be confirmed through this study. During the initial interactions with Sonic Straws, the players engaged predominantly with the preset sounds, which offered surprises and in consequence stimulated curiosity. This curiosity appeared to motivate players to explore the system through normal drinking actions, e.g. sipping via one of the straws. The generated sound as a result of the drinking actions then gradually let players become aware of how to play sounds via drinking. As such, the experience began with initial "regular" drinking that resulted in playful sounds that facilitated a lusory attitude in the player. This attitude, which can serve as a vehicle for play according to Suits (1984), was important to fuel the next moment of the experience. As the Sonic Straws system allowed to go further than only playing one playful sound, players experienced connected sonic interactions through two straws that could trigger sounds from a preset sound set: each preset sound source could either connect with each other or respond to each other. This appeared to facilitate the next step, where the lusory attitude seemed to motivate players to explore the system further: they began playing with the two straws and further explored what would happen if they modified their drinking actions. For example, players aimed to perform a harmonious melody by changing sipping paces, mediating the amount of beverage consumption by changing duration, adjusting the releasing time while sipping, moving the mouth between two straws, etc. In other words, the preset sounds that facilitated a lusory attitude led participants to explore how they could modify their drinking actions. I note that the playful experience framework (Lucero et al., 2013) stress how important "exploration" is as part of play, however, the author describe it as "investigating an object or situation", here I extend this prior work by adding that exploration can also investigate not only an object or situation, but the mechanics of an existing everyday activity, i.e. drinking. As such, I argue that play was further facilitated through sounds that reframed drinking actions as playful exploration.

After becoming more familiar with the system, players also appeared to explore the potential of the system for play further by setting up various sounds of their own. They selected these sounds based on the different everyday contexts the beverages are consumed in, including considering their emotions, past personal experiences, and their own and their partner's drink and sound preferences. As such, players aimed to map their personal drinking styles with their personal tastes, where taste was referring to both sound and beverage preferences. As such, the aforementioned exploration around drinking actions was extended to personal sounds that participants used to express themselves: through the mapping between the sounds they played and the beverages they chose. Such self-expression has been previously described as another key element of playful experiences, articulated as "manifesting oneself creatively" (Lucero et al., 2014). However, in the context of pervasive play (Montola et al., 2009), this mostly occurs through games that are placed within everyday life, but still occur independently. Here, I extend this prior work by highlighting that systems can facilitate playful experiences by supporting players to express themselves through the ability to generate novel personalized mappings between digital play elements and everyday actions. Supporting such self-expression through personalization has been previously highlighted as being useful as it can facilitate a spontaneous re-appropriation loop in a variety of new contexts (Ostuzzi et al., 2017). This in line with the previous design tactics (in Chapter 4) that varied sounds can support different self-expression through eating actions as a way to facilitate playful experiences. As such, I recommend for designers to consider playful and personalized sounds to move players from drinking surprises to self-expression via drinking.

6.7.2 Tactic 2: Expand the social "magic circle" of play through amplified playful sounds as a way to facilitate experiencing drinking as social play

Sonic Straws supported positive social interactions through amplified playful sounds. When participants drank beverages using Sonic Straws, the sound was heard by others more vividly and loudly than a usual drinking noise. This served as a facilitator for social interaction, that is, the augmented sounds made others aware that someone was drinking, making people curious what they were drinking and facilitated inviting others to join in and sharing of beverages. Moreover, Sonic Straws facilitated laughter around (mis-)coordination when aiming to achieve harmonious sounds, and supported discussion among additional household members through the use of sounds. We note that one's perception of sounds usually depends on the perception of acoustic phenomena through a cognitive process (Dubois et al., 2006), where the interpretation of sounds can be influenced by physical, behavioural and psychological factors in different locations. Therefore, when deploying Sonic Straws in a social setting where the sound generated through user's self-expression can be heard and interpreted by other household members in the collocated environment, the other householders might have different interpretations of the sound. This might cause additional verbal communication and promote social connection. Interestingly, although our participants might have had different interpretations, Sonic Straws appeared to increase the participants' awareness of their partner's moods and motivated them to care for each other. According to Montola et al. (2009), pervasive play can blur the line between the magic circle of play and everyday life by expanding social boundaries of traditional digital games through pervasive computing. Here, I extend this theory by demonstrating that the social "magic circle" of play can be expanded by this playful beverage-based gustosonic system that amplifies playful sounds compared to original drinking, where participants can choose beverages and playful sounds combinations that facilitate various interactions with others. This in line with a prior design tactic in Chapter 5 that designing playful social gustosonic experiences can enrich social play through eating together.

As such, I recommend that designers could consider that the amplified playful sounds can expand the social magic circle of play while facilitating playful social experiences around drinking through experiencing drinking as social play.

6.7.3 Tactic 3: Integrate sounds as an opportunity to reframe drinking actions as play to facilitate reflection on everyday drinking activities

I argue that Sonic Straws became integrated with the players' everyday life, mainly due to the pervasive nature of drinking activities, which in turn facilitated reflection on their everyday drinking activities. Drinking is an essential daily activity for everyone regardless of age, gender, race and cultural background (Campbell, 2004). This stands in contrast to many other pervasive play experiences that are often specific to a particular context or targeted at a particular user group, possibly pervading everyday life (McGonigal, 2003; Montola et al., 2009) but not integrating with it. In contrast, Sonic Straws through the pleasure associated with its augmented multisensory experience appeared to integrate with everyday life and this in turn seemed to reframe everyday drinking activity as play (Huerga et al., 2016). Every time the user drank a beverage with Sonic Straws, the user engaged with the playful system, giving rise to the opportunity to naturally trigger explorations of the system and reflection on everyday drinking experiences. Such an integrated experience is in line with the prior theory of unselfconscious interaction (Wakkary et al., 2016), which describes "a form of interaction facilitated by ongoing and incremental intersection with interaction design artifacts that over time and even unknowingly lead to improvements in everyday settings." This prior research has mostly focused on instrumental improvements (Kim et al., 2016). With my work, I extend this theory by highlighting the potential to also facilitate experiential improvements. Similarly, Sonic Straws also speaks to prior research around interaction design for reflection that suggests the integration of reflection facilitators with everyday life in order to better support everyday self-reflection (Mols et al., 2016a). As reflection always needs time (Fleck and Fitzpatrick, 2010), I argue that integrating opportunities for reflection through gustosonic experiences offers an opportunity to encourage reflections in an unobtrusive way (Mols et al., 2016b). Therefore, I argue that a playful beverage-based gustosonic system can reframe drinking actions as play by allowing participants to engage with drinking activities through play design, rather than through the creation of a completely new game. Taken together, the findings above revealed the potential for designing playful gustosonic systems around everyday practices that can facilitate reflection on such everyday practices. I therefore recommend that designers could consider integrating sounds as an opportunity to reframe drinking actions as play to facilitate reflection on everyday drinking activities.

6.8 Conclusion

In this case study I have introduced Sonic Straws, a playful beverage-based gustosonic system in the form of an augmented cup that allows users to experience playful personalised sounds via drinking beverages through straws. With Sonic Straws, players can use personalised sound clips to generate melodies through two straws at the same time. I conducted an in-the-wild study with 8 participants for one week to understand how users experienced the beverage-based playful gustosonic system. The results suggest that the system supported self-expression via playful drinking actions, facilitated pleasurable social drinking moments and promoted reflections on participants' everyday drinking activities.

This third case study reveals that integration of the playful gustosonic system with everyday drinking activities can reframe everyday eating/drinking activities as a type of pervasive play and promote reflection on everyday drinking experiences.This case study led me towards a more comprehensive and deeper understanding of the design of playful gustosonic experiences.

In the next chapter, I will present a framework for designing playful gustosonic experiences based on the results from the three case studies.

Chapter 7

The Design Framework

IN this chapter, I present the conceptual design framework for playful gustosonic experiences visualised in a 5*4 diagram (Figure 7.1). The first row of the diagram presents the four time spans of a playful gustosonic experience. The second row of the diagram presents the four key experiential qualities in relation to each time span. The third row presents the design examples that highlight the experiential quality. The last row presents the design features of each experiential quality that can guide designers when designing future playful gustosonic experiences. In the following section, I introduce the framework in detail.

7.1 Towards designing a playful gustosonic experiences framework

The framework has been created based on the practical knowledge I gained through the design process, and implementation and analysis of the three case studies that I have described in previous chapters. The main method used to create this framework was to iteratively analyse the qualitative findings from the three case studies. As qualitative research is a core approach to understanding technology as experience (McCarthy and Wright, 2004), a deeper understanding of the quality of playful gustosonic experiences has played a crucial role in developing the design framework. This is because qualitative research involves the collection of subjective or open-ended data that can develop a set of common and recurring themes. These themes can facilitate unexpected but valuable design opportunities and potential theoretical advancements (Creswell and Creswell, 2017; Dalsgaard and Dindler, 2014). As such, I have utilised an iterative analysing

Temporality	Initial moment	In the moment	Shared moment	Beyond the moment
Experiential quality	Exploration of eating sounds	Self-expression via eating actions	Relatedness of eating together	Reflections on everyday eating activities
Design examples	iScream! WeScream! Sonic Straws	iScream! WeScream! Sonic Straws	WeScream! Sonic Straws	Sonic Straws
Design features	**Incongruence of sounds** can elicit curiosity	**Ambiguous** interface can direct attention back to eating/drinking actions	**Independent devices with an interdependent sound system** can prompt new ways of eating/drinking together	**Personalisation** can give space for reflection
	Ephemeral nature of food can facilitate sound exploration	**Looseness of control** can facilitate musical self-expression	**Amplified sounds** can surprise bystanders through an eating/ drinking spectacle	**Integration of** a gustosonic experience into everyday eating/ drinking activities can be a source of happiness

FIGURE 7.1: The design framework for playful gustosonic experiences.

approach (Ryan and Bernard, 2003) towards an understanding of the findings that I have obtained from the three case studies: iScream!, WeScream! and Sonic Straws.

The design framework consists of four categories: temporality, experiential qualities, design examples and design features of playful gustosonic experiences. Temporality refers to the user's process of experiencing playful gustosonic experiences through four different time spans, I call them: initial moment, in the moment, shared moment and beyond the moment. The experiential qualities are used to describe different core qualities that players might appreciate in each time span: the exploration of eating sounds at the initial moment, the self-expression via eating actions in the moment, the relatedness of eating together at a shared moment and reflection on everyday eating activities beyond the moment.

To guide HCI practitioners in creating future playful gustosonic experiences, eight design features are illustrated for the experiential qualities of the playful gustosonic experiences:

- Incongruence of sounds can elicit curiosity
- Ephemeral nature of food can facilitate sound exploration
- Ambiguous interface can direct attention back to eating/drinking actions
- Looseness of control can facilitates musical self-expression
- Independent devices with an interdependent sound system can prompt new ways of eating/drinking together
- Amplified sounds can surprise bystanders through an eating/drinking spectacle
- Personalisation can give space for reflection
- Integration of a gustosonic experience into everyday eating/drinking activities can be a source of happiness

These design features are based on my design knowledge from the implementations and analyses of the three case studies; hence they represent a suggested way forward for practitioners such as game designers, food designers and people from the hospitality industry and interaction designers interested in designing playful gustosonic experiences. These design features do not guarantee success, but should rather be seen as a useful way to begin an investigation, as they have been useful in my work. As such, the design framework has descriptive power (through the experiential qualities, i.e. they can help researchers describe what they might observe through providing a vocabulary) and prescriptive power (through the design features, i.e. they can guide designers when making design choices in their practice).

7.2 Design process

To generate the framework, I revisited all the findings from the three case studies, iScream!, WeScream! and Sonic Straws. I gathered together the 42 findings from the three case studies and conducted a thematic analysis. I iteratively clustered these into higher level groupings based on how the participants experienced the playful gustosonic systems differently. Finally, I generated the four key experiential qualities of playful gustosonic experiences. Table 7.1 shows each finding as it relates to each experiential quality of playful gustosonic experiences.

TABLE 7.1: The 42 findings from the three case studies and their relationships with the four experiential qualities of playful gustosonic experiences.

Case study	Findings	Experiential qualities
iScream!	iScream! facilitated curiosity about what sounds eating would produce.	Exploration
	iScream! provided additional eating rewards.	Exploration, reflection
	iScream!'s exploration was facilitated by the mismatch between sound and eating.	Exploration, expression
	iScream!'s food transformation contributed to sound exploration.	Exploration, expression
	iScream! facilitated transition into a fantasy world.	Exploration, expression
	iScream! offered relaxation.	Exploration, expression
	iScream!'s sounds facilitated exploring different ways of eating.	Exploration
	iScream! altered eating speed.	Expression
	iScream! increased food appetite.	Expression
	iScream! facilitated playful experience without visual stimulus.	Exploration, expression
	iScream! shifted eating to the foreground of attention.	Exploration, expression

	iScream! facilitated awareness of eating behaviour.	Expression, reflection
WeScream!	WeScream! offered challenging yet enjoyable experiences.	Exploration, expression, relatedness
	WeScream! supported coordinated eating actions through multiple strategies.	Exploration, expression, relatedness
	Participants enjoyed a slow eating pace through competition.	Expression, relatedness
	Participants modified sound sources to increase enjoyment.	Expression
	WeScream! prompted attention to each other's eating behaviours.	Expression, relatedness
	Ambiguity of sounds led to a focus on the food.	Expression, reflection
	WeScream! facilitated reminiscing about past social experiences.	Relatedness, reflection
	Preparing WeScream! brought participants together.	Exploration, expression, relatedness
	WeScream! increased face-to-face communication.	Relatedness, reflection
	WeScream! was used for comfort and emotional support.	Relatedness, reflection
	WeScream! fostered intimacy in partnerships.	Relatedness
	WeScream! facilitated reflection on social bonding.	Relatedness, reflection

Sonic Straws	Participant enjoyed aligning personalised sounds with the taste of the beverage.	Expression
	Participants extended playful drinking experiences through personalised sounds.	Exploration, expression
	Participants were rewarded with different sounds with each sip.	Exploration
	Participants engaged in self-expression through turning sipping into music-making.	Exploration, expression
	Participants turned drinking into a form of sound's narrative potential.	Expression, reflection
	Participants enjoyed how the sounds could turn drinking into a relaxation opportunity.	Expression, reflection
	Participants enjoyed coordinating drinking actions via playing with sound together.	Expression, relatedness
	Participants inferred their partner's emotions based on sound selection.	Expression, relatedness, reflection
	Sonic Straws's sounds facilitated social play over beverages.	Expression, relatedness
	Sonic Straws's sounds facilitated sharing beverages experiences.	Expression, relatedness, reflection

	Sonic Straws's sounds made participants curious about their partner's taste in beverages.	Expression, relatedness
	Sonic Straws's sounds created opportunities for conversation.	Expression, relatedness
	Sonic Straws motivated participants to drink more frequently and proactively.	Expression, reflection
	Sonic Straws brought more awareness to everyday drinking activities.	Reflection
	Sonic Straws facilitated reminiscence through personalised sounds.	Expression, reflection
	Sonic Straws's sounds were part of the gift-giving when making a drink for someone.	Relatedness, reflection
	Sonic Straws inspired a desire for further personalisation.	Expression, reflection
	Sonic Straws led to reflection on smart voice-based agents at home.	Reflection

To finalise the framework, I conducted multiple group discussions with colleagues to refine the categories and the visualisation form of the framework in order to represent its information in a clear way. One of the initial designs of the framework included the four key experiential qualities as four points positioned in a triangle-shaped structure. I marked an interaction loop with related design features between each experiential quality. Then I conducted an in-lab evaluation of the framework with five experts (two senior interaction design researchers, two interaction designers in HCI, one interaction designer in HFI). Although all experts highlighted that the experiential qualities were very descriptive, they believed that the visualisation of the framework was complex for designers to understand (see Figure 7.2). This feedback motivated me to refine the framework. To achieve this, I revised the framework using a 5*4 diagram that carries descriptive text, drawing inspiration from existing literature within HCI (Altarriba Bertran et al., 2020; Derix and Leong, 2019) that uses such a diagram to make a set of design articulations accessible to designers. The revised design framework has four categories presented in the diagram, which I hope that designers can readily use during their design process (Figure 7.1).

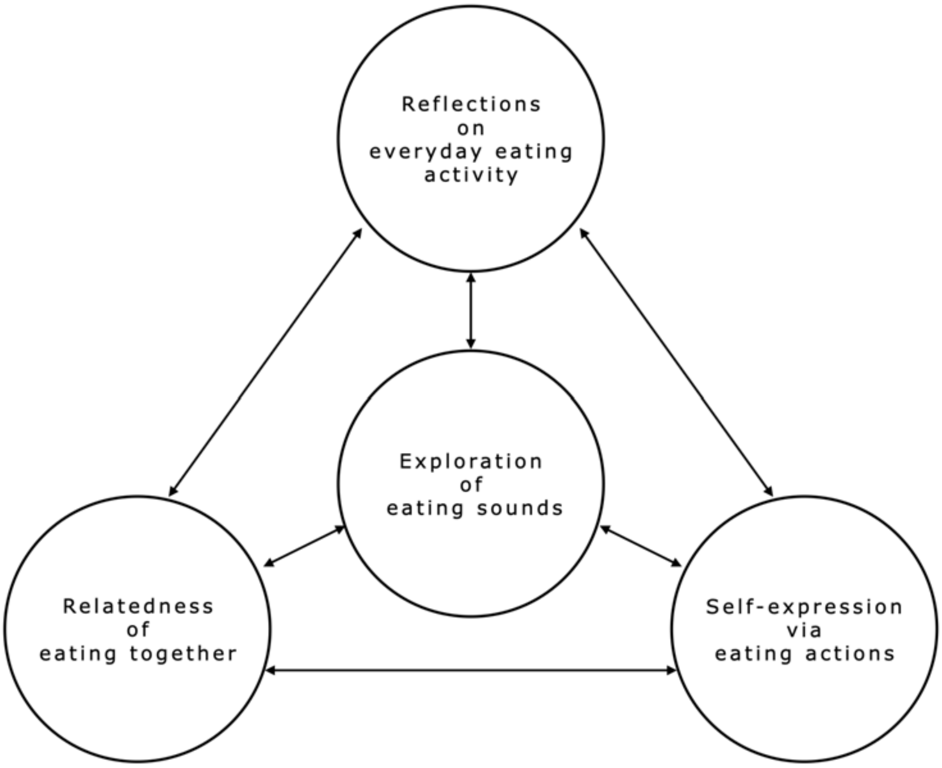

FIGURE 7.2: Initial version of the design framework for playful gustosonic experiences

7.3 Four key experiential qualities of playful gustosonic experiences

In this section, I provide more details on each experiential quality. Grounded on the theoretical foundation (detailed in Chapter 2) that highlights the importance of temporality in designing UX (McCarthy and Wright, 2004), researchers can identify the differences between initial and prolonged experiences in the ways users undergo overall experiences. Therefore, to understand playful gustosonic experiences in depth, I turn to understanding the temporality of playful gustosonic experiences.

In my three case studies, I used off-the-shelf food materials. The players could consume the food/beverages without any technology distractions like having to wear an AR headset (as previously proposed; Arnold et al., 2018), or attach a sensor to the face (as previously proposed; Koizumi et al., 2011), or take out their smart phone (as previously proposed; Juarascio et al., 2015). Therefore, the players could experience a playful gustosonic experience while eating/drinking. This is in line with a previous study (Wang et al., 2020), where sounds have appeared to have the greatest influence on the eating experience when it was played during eating (in contrast to before or after eating); this is because temporal congruence between sound and eating/drinking plays a key role in multisensory integration (Spence, 2011). As such, I argue that the temporality of the food being consumed plays an important role in understanding (and hence designing) playful gustosonic experiences.

HCI researchers have already paid attention to the temporality of UX, as UX is often characterised as "subjective, context-dependent and, most importantly, dynamic" (Odom et al., 2018). According to Roto (2011), UX-related technologies can be studied through different temporal lenses: anticipated UX (before first use), momentary UX (visceral response to use), episodic UX (reflection on an experience) and cumulative UX (usage over multiple times). Similarly, Karapanos et al. (2009) proposed a theoretical model that describes the user's process of using new technology shifting through three stages: orientation, incorporation and identification. The orientation stage refers to a user's initial experiences when encountering new features of the technology. In the incorporation stage, the new technology has become meaningful in the user's everyday life and the user increasingly reflects on ways of using the technology in diverse contexts. In the identification stage, this new technology is connected to the user's desired self-identity. Inspired by these theoretical works, I argue that playful gustosonic experiences can be approached through four experiential qualities based on temporality: exploration of eating sounds at the initial moment, self-expression via eating actions in the moment, relatedness of eating together at a shared moment and reflection on everyday eating activities beyond the moment. I discuss each experiential quality in the following subsections.

7.3.1 Exploration of eating sounds at the initial moment

The first experiential quality, exploration of eating sounds, was informed by the PLEX framework (Lucero et al., 2013), where exploration refers to the conscious investigation of an environment, object, or situation. In this thesis study, the digital sounds in a playful gustosonic system play a crucial role in adding a component to be explored while eating/drinking. I found that players questioned the taste of food/beverages while playing with sounds and the rationale behind generating sounds through eating/drinking. This experiential quality is in line with the definition of exploration in the PLEX framework. Based on the findings from all three case studies, I propose that exploration is derived from initial interactions with a gustosonic system. In all case studies, players mentioned that the gustosonic experience was different from the usual eating or drinking experience because the gustosonic system appeared to facilitate a sense of curiosity about how the sound would change next depending on the act of eating/drinking. With gustosonic systems, there is always potential for incongruence between people's expectations of what food should sound like and what they hear when experiencing the gustosonic system. According to the study of crossmodal interaction in cognitive neuroscience, people can establish congruence between their senses automatically (Spence, 2011). For example, people can associate eating ice cream with licking sounds derived from mastication before eating ice cream. When consuming the ice cream, people will compare the in the moment experience, which may involve taste, smell and sound derived from mastication of ice cream, to the expectation built before the eating ice cream. In my case studies, people experienced incongruence between the expected sound of eating regular ice cream and what they heard. All players found this incongruence intriguing. This motivated them to explore the gustosonic system further. In response, this exploration can therefore function as a link to the next experiential quality, self-expression via eating actions in the moment, which I explain next.

7.3.2 Self-expression via eating actions in the moment

The second experiential quality, self-expression via eating actions, is grounded in the prior work of Mitchell et al. (1934), who described play as self-expression. In this thesis study, the experience of self-expression is derived from eating/drinking facilitated by playing with sound. According to the PLEX framework (Lucero et al., 2013), the experience of self-expression is derived from manifesting oneself creatively and it can facilitate individuals to identify themselves through designing, constructing, modifying and personalising. Through engaging with playful gustosonic systems, players can express themselves via modifying eating/drinking actions spontaneously and with personalised sounds proactively. In all case studies, the participants played with different paces of eating/drinking actions as well as consuming different amounts of food/beverages in order to musically express themselves via eating/drinking actions in the moment. Therefore, this self-expression via eating actions can be seen as a new form of play (Mueller et al., 2020b).

The term "in the moment" is deliberately used to stress being in the present time, as advocated in the practice of immersion in pervasive play (Jegers, 2007), because participants were focusing on what they were hearing (and eating/drinking) right at that moment, not dwelling on what sounds (and foods) they had missed in the past, as they would never be able to bring those back. I also find that the ephemeral nature of the taste sensation is nicely underlined by the fleeting nature of the sound; hence the stress on "in the moment". For example, in the iScream! study, once players found out that when they ate a bite of ice cream they generated a different sound each time, that allowed them to receive pleasure from identifying a specific eating pattern to play with different sounds. In WeScream! the player pairs enjoyed the challenges of creating a harmonious piece of melody through coordinated eating actions. During eating, they came up with multiple strategies to differentiate their eating actions, for example, by the more skilled player triggering rhythmic chords or licking ice cream as slowly as they could to generate a better and clearer melody. Through varying their eating actions, players were able to compose a unique melody through playing with food at the same time. Moreover, in Sonic Straws the players were able to personalise digital sounds for the gustosonic system. This supported their self-expression and differentiation from others in certain settings, for example, allowing them to show off to their friends or support each other for comfort.

7.3.3 Relatedness of eating together at a shared moment

The third experiential quality, the relatedness of eating together, comes from commensality, which refers to "the positive social interaction that is associated with people eating together" (Fischler, 2011). Relatedness has been defined as creating a sense of relationship, friendship, or intimacy with someone (Lucero et al., 2014). In general, the experience of relatedness emerges from social interaction (Hicks and King, 2009). In this thesis, the digital sounds appear to have served as a vehicle to support positive social interaction while eating together. In the studies of WeScream! and Sonic Straws, players reported that engaging with the playful gustosonic system with their partner could facilitate positive social interaction via eating together at a shared moment, for example, provoking conversation, increasing face-to-face communication, fostering intimacy in the partnership, sharing beverages with their partner or surprising a bystander via an eating/drinking spectacle. Therefore, the term "shared moment" highlights that the players could experience "being in the same time" while eating/drinking to facilitate a sense of relatedness of eating together. In the study of WeScream! the players composed rhythmic melodies while eating ice cream together. The players mentioned that the challenges of creating enjoyable melodies through coordinated eating actions promoted attention to each other's eating behaviour and facilitated face-to-face communication while eating together. In Sonic Straws, the players shared beverages with their partner through playing with sound together which fostered intimacy or interacted with a bystander through generating playful sounds.

I note that people's interpretation of sounds is subjective (Dubois et al., 2006) and this interpretation can be influenced by physical, behavioural and psychological factors in different contexts (Yu and Kang, 2010). When the player generates sounds via eating/drinking, the sounds can be heard (often louder than the original sounds that food would make) and interpreted by bystanders or their partner in the co-located environment (facilitated by the fact that the sounds are incongruent, i.e. unexpected by others in regards to the food/drink they are coming from) and the bystanders or partner might have different understanding of the sounds and the eating/drinking spectacle. This different understanding might lead to verbal interaction and increase social connection. In other words, engaging with a playful gustosonic system can establish an environment that offers rich opportunities to facilitate social interaction, for example, provoking conversation, facilitating collaborative play or fostering commensality. In summary, players can experience the relatedness of eating together at a shared moment.

7.3.4 Reflections on everyday eating activities beyond the moment

The final experiential quality of playful gustosonic experiences is concerned with reflection. The term "reflection" has been defined as "recollecting a series of previous experiences, events, stories, etc., and putting them together in such a way as to come to a better understanding or to gain some sort of insight" (Baumer, 2015). Reflection is grounded in the method of "making strange" or defamiliarisation, which is an artistic strategy originally introduced by Gunn (1984). He proposed a method of "defamiliarisation to 'make objects unfamiliar' to increase the difficulty and length of perception because the process of perception is an aesthetic end in itself and must be prolonged." In HCI, Gaver et al. (1999) employed defamiliarisation to design probes that facilitated participants to reflect on their everyday life. Moreover, Bell et al. (2005) employed the making strange method for understanding the design of domestic technologies through making everyday items strange to facilitate reflection. In this thesis study, the use of playful sounds with food made habitual eating/drinking activities strange.

In this thesis study, the experiential quality of reflection was mainly derived from the case study of Sonic Straws. With Sonic Straws, I found that the system served as a facilitator of self-reflection in everyday life as players reported on their reflection experiences (Mols et al., 2016a). For example, some players regarded Sonic Straws as a utility system that made drinking playful as well, so they mentioned that the system motivated reflection on their everyday water intake. Others saw Sonic Straws as a novel playful instrument for self-expression while drinking, so they personalised the playful sounds based on certain factors such as their emotions or personal past experiences. This in turn motivated some players to reflect on corresponding situations where they had heard sounds that were associated with drinking experiences. Intriguingly, with iScream! and WeScream! players also had reflection: with iScream! some players enjoyed playful sounds as an additional hedonic reward for eating, while with WeScream! some players relished putting in effort to pursue a sense of completing a harmonious melody through eating together. Through understanding these reflection experiences above, the term "beyond the moment" is used to emphasise that the player not only reflects on the current eating/drinking action, but also reassesses previous activities, thoughts and feelings regarding habitual behaviours (e.g. eating/drinking activities) in everyday life.

In the next section, I describe the set of design features of playful gustosonic systems and how they have been derived from my three case studies.

7.4 Design features of playful gustosonic experiences

In the previous section, I have presented the four key experiential qualities of playful gustosonic experiences. These four experiential qualities could help designers to consider each time span of playful gustosonic experiences and therefore be a starting point for understanding the features of playful gustosonic systems. In this section, I present eight design features in the form of actionable implementation suggestions that could guide the design of future playful gustosonic experiences.

7.4.1 Design features for exploration of eating sounds at an initial moment

Through the iterative analysis of the findings from the three case studies, I found that the experiential quality of the exploration of eating sounds has emerged in all three case studies. In this sections, I introduce two design features each with three examples (from iScream!, WeScream!, and Sonic Straws) that serve to explain this quality. The design features are: the incongruence of sounds can elicit curiosity and the ephemeral nature of food can facilitate sound exploration.

7.4.1.1 Incongruence of sounds can elicit curiosity

The first design feature is concerned with the incongruence of sounds in facilitating the exploration of eating/drinking sounds at the initial moment. Prior works in neuroscience have proposed that people can perceive the world through different sensorial modalities (such as sight, sound, touch, smell, taste) because our brains can connect information from multisensory inputs, while the sensory information usually corresponds to the same identity (Spence, 2011; Velasco et al., 2016). People deal with this sensory information based on the compatibility of crossmodal correspondences, as they can build congruence between two senses automatically (Spence, 2011; Wang et al., 2020). For example, we can hear the sound of sea waves and associate this with the features of the sea such as blue colour, seafood and saltiness (semantic correspondence; Doehrmann and Naumer, 2008). We can also perceive the crunchy sounds of chips and in response the sounds may create a specific expectation such as the quality of the chips (crossmodal correspondence; Spence, 2011). Congruent experiences occur when our perception matches our expectation (Spence, 2011). However, a feeling of incongruence can occur when people perceive mismatched sensory experiences. In the field of HCI, researchers have exploited the benefits of incongruence for enriched experiences. For example, Finnegan et al. (2016) demonstrated that using an incongruent audio-visual display could improve the perception of distance in virtual environments. Ludden and Schifferstein (2007) showed that designing appropriate incongruence can evoke surprise and humour to support hedonic experiences. As such, I believe that incongruence can be a desirable design resource for playful multisensory interactions.

In all my three case studies, players who had a normal understanding of food/beverages could relate to some features related to food/beverages; for example, ice creams can be related to the features of being soft and having a creamy mouthfeel before eating. People's understanding of crossmodal correspondences can build a feeling of congruence between multisensory experiences of ice cream and expectations of ice cream before engaging with the playful gustosonic system. However, when players perceive an incongruent sound that differs to what they originally expected, they can experience surprise, resulting in curiosity what caused this incongruence. The players then explore the rationale for the generated sounds or repeat the sounds to explore further etc., this in turn inviting the player to further exploration. This curiosity fuels the exploration of eating sounds, the aforementioned design quality. As such, designers could consider incongruence as a key design feature to support the design of playful gustosonic experiences. Also, designers should stay aware that utilising a licking sound or augmented food sounds that match the food (e.g. licking ice cream sounds as known from licking ice cream) could facilitate instrumental gustosonic experiences. This in line with prior work that aimed to enrich the multisensory tasting experience (Spence, 2021). As such, designers could consider using congruent sounds for instrumental gustosonic experiences and incongruent sounds for play.

7.4.1.2 Ephemeral nature of food can facilitate sound exploration

An ephemeral user interface refers to an interface element that incorporates materials that can evoke a rich multisensory perception which lasts for a limited time only (Kwon et al., 2015). The two features of ephemeral user interfaces are their time-based nature and the multisensorial qualities of the material used for interaction. In my work, I utilised regular ice cream as an edible interface combined with capacitance-sensing technology. In iScream! and WeScream!, when participants ate the ice cream there was always a differently shaped piece of food left to be explored as a result. As players were licking the ice cream, it made a sound but the ice cream also diminished. While the ice cream was melting, players had to lick quickly before the ice cream fell off the cone, which facilitated exploration of the interplay between what became a soundscape and the food. With Sonic Straws, participants consumed different amounts of water each time and the episodic sipping experience was changed via the exploration of the sounds. With WeScream! participants said that because the ice cream melted over time, they had to engage with the ice cream consistently to identify the eating patterns for composing sounds, which in turn increased the excitement of eating together. Interestingly, this finding confirms a prior theory that an edible interface can offer intriguing embodied interactions while enriching social enjoyment (Maynes-Aminzade, 2005). Moreover, the ephemeral nature of an edible interface can be exploited to benefit playful eating interactions by encouraging self-guided exploration. For example, Wei et al. (2011a) with their interactive system Foodie found that players could actively participate in exploring food creation through an interactive 3D food-printing system. However, designers could also consider the quantity of food used and issues related to overconsumption of food while designing an edible interface. Prior work has highlighted the limitations of an edible interface; for example, Maynes-Aminzade (2005) found that players tended to engage in less interaction with food if they felt full. Therefore, designers should carefully choose food materials and limit them to suitable quantities. Nevertheless, the ephemeral nature of food can be a key design consideration to facilitate the exploration of eating sounds.

7.4.2 Design features for self-expression via eating actions in the moment

The experiential quality of self-expression via eating action has also emerged from all three case studies. I here introduce two design features each with three examples (from iScream!, WeScream! and Sonic Straws) that serve to explain this quality: an ambiguous interface can direct attentions back to eating/drinking actions and looseness of control can support musical self-expression.

7.4.2.1 Ambiguous interface can direct attention back to eating/drinking actions

Gaver et al. (2003) proposed that "ambiguity can be a useful resource for design to encourage close personal engagement with systems". In my three case studies, the ambiguity came from two aspects: ambiguity in the sound's feedback and ambiguity in the artefact's appearance. These two aspects of ambiguity appeared to motivate players to become aware of their eating/drinking actions through playing with sounds while eating/drinking.

Ambiguity in the sound's feedback

One interpretation of a piece of sound is often subjective because our perception of sounds depends on the perception of acoustic phenomena through cognitive processes (Dubois et al., 2006). In the case study of iScream! I found the players had different interpretations of the sounds while eating ice cream. For example, when one player heard a monster's roaring sounds, the player described the roaring sound as a "wind sound" as well as "feeling cold" while eating ice cream. Moreover, in all the three case studies some players reported that they became aware of a sound delay glitch in the generated sounds but they did not know the exact cause. This appears to have motivated the players to focus on eating/drinking actions rather than just playing with sounds, balancing the distractions from pure entertainment and from food. As such, the sound's feedback in the playful gustosonic system created ambiguity of (sound) information to offer players new ways of interacting with food.

Ambiguity in the artefact's appearance

In the three case studies, the artefact's appearance created ambiguity through the relationship between the expectation of how the food was meant to sound and the sound that was actually heard, causing players to pay attention to the food during eating. For example, for iScream! and WeScream! I 3D-printed a cone with a light wood filament to mimic the look and feel of a regular ice cream waffle cone. Adding playful sounds as an incongruous quality to a naturalistic ice cream eating experience generated ambiguity for the players. Players reported that they appreciated the tactile experience of the 3D-printed cone because it felt like a real waffle cone. By mimicking the regular look and feel of an ice cream cone, the iScream! and WeScream! systems not only allowed people to intuitively eat the ice cream, but also drew players' attention back to the food via sound. Moreover, with Sonic Straws the artefact's appearance created an ambiguity of context, allowing the players to use the system in a more flexible way. For example, some of the players used the system as a playful instrument to surprise any bystanders or partners. Some regarded the system as a playful drinking device for reflecting on everyday drinking activities.

7.4.2.2 Looseness of control can facilitate musical self-expression

According to Benford et al. (2020), looseness of control in an interaction describes a relationship between the performances of the human and of the technology. From the technology perspective, looseness of control refers to an imprecise recognition of the user's actions such as sensor noise, unpredictable data mappings, etc. In contrast to looseness, tightness is regarded as a crucial factor in designing interactive systems, which means precise and direct control of the technology. However, prior works have suggested that looseness of control can be a desirable quality for musical self-expression, in particular, in improvisation for musicians (Benford et al., 2020). In response, in my work I have found that a degree of looseness of control from technology perspective can facilitate musical self-expression in different ways. In the three case studies I utilised capacitance-sensing technology to sense the food material being consumed by the player. When the player's mouth made contact with the food, the sensed capacitive data was mapped to trigger sounds in the sound system. Although the sensor could detect the data rather accurately and precisely, the designed sound system in each case supported different degrees of looseness of control. The control of the sounds in iScream! was mostly tight because the sensed data was mapped as a simple trigger to play one of four selected playful sounds. When the player took a bite of the ice cream, a complete 3-second sound clip was played. However, the sensitivity of the capacitance-sensing technology offered a degree of looseness. If the player ate too fast and the eating interval between each bite was shorter than 3 seconds, the sound system would produce a mismatching mapping between sounds and eating actions. Therefore, the player could actively modify their eating action for playing with the sounds. In WeScream! the looseness of control was the result of the mapping of the sensed capacitance data to a major pentatonic musical scale in the sound system. As the sound system could generate different timbres (i.e.

different instruments) along with a major pentatonic musical scale, the players could hear varied sounds per bite when performing licking-on and licking-off actions. This enabled the players to either improvise sounds while eating together (looser control) or generate eating strategies to better play a continuous melody together (tighter control). Moreover, utilising multiple capacitance-sensing capabilities of the advanced sensing microcontroller supported two straws working simultaneously in Sonic Straws. The player could either create playful personalised sounds with one single straw or generate a connected sound sequence via moving their mouth between the two straws. As such, the system was designed to offer both tight control and loose control. Looseness of control may also arise from the user. In my work, the three playful gustosonic systems offered players the opportunity to experience eating/drinking as play. Players could play loosely with sound by eating the food slowly and mindfully. As a result, the players could obtain better musical self-expression experiences via eating/drinking actions.

Overall, designers could consider the basic sound parameters (i.e. pitch, duration, timbre, loudness, position in space) when designing the aspect of control in a sound system. For example, designers could utilise the rhythm of sound to offer a tighter control of players' eating pace. Prior work already showed the effect of music tempo on eating duration (Wang et al., 2020): a slower tempo could increase the eating duration. Future work could use a slower tempo of sounds to facilitate eating slowly, which could be a design strategy for mindful eating experiences (Donovan, 2018). Additionally, designers could consider the ephemeral nature of food materials for a mindful eating context. For example, eating ice cream slowly may be less desirable because it will melt.

7.4.3 Design features for relatedness of eating together at a shared moment

In this section, I introduce two design features focusing on mainly two examples (WeScream! and Sonic Straws) to illustrate the experiential quality of the relatedness of eating together at a shared moment. The two design features are: independent devices but interdependent sound systems can prompt new ways of eating/drinking together and amplified sounds can surprise bystanders through an eating/drinking spectacle.

7.4.3.1 Independent devices with an interdependent sound systems can prompt new ways of eating/drinking together

In the case studies of WeScream! and Sonic Straws, players mentioned that they enjoyed engaging with the playful gustosonic system while eating/drinking together. It appears this was the case because the playful social gustosonic systems (WeScream! and

Sonic Straws) facilitated positive social eating interaction via the interdependent sound system through the independent devices. For example, with WeScream! I found that people seldom shared one ice cream scoop if they were eating from a waffle cone. However, people like to eat ice cream together as a social activity (Spence et al., 2019b). Inspired by this seemingly cultural eating norm, I designed WeScream! to consist of two independent cones, as well as offering cone-to-cone communication through a wireless connection. An interdependent sound system was designed to support a collaborative way to play with sounds. Therefore, players were able to experiment with various ways to engaging with the system in order to increase social interactions while eating together. For example, players could have more face-to-face communication around how to create social gameplay with the system. They even came up with strategies to generate a piece of legato melody by having the more "skilled" player trigger the main rhythmic chords for both players. Moreover, the players paid attention to each other's eating actions through the challenges of playful collaborative eating. This resulted in the players spontaneously performing symmetrical eating actions in order to build an enjoyable melody via eating together. In the case study of Sonic Straws, I found that the two independent straws but interdependent sound system supported collaborative playful drinking experiences by sharing the beverages with others. For example, players mentioned that they shared beverages through playing connected sound sequences (i.e. how two sounds could respond to each other). This confirms prior work that suggested interdependence in cooperative play can enhance social engagement between players (Harris and Hancock, 2019; Isbister et al., 2017). Therefore, independent devices but interdependent sound systems can prompt new ways of eating/drinking together to facilitate the relatedness of eating/drinking together.

7.4.3.2 Amplified playful sounds can surprise bystanders through an eating/drinking spectacle

In the three systems, the playful sounds accompanying the eating were louder than the regular eating sounds. This was the result of the laptop's amplifier with the corresponding speaker in iScream! and the in-built amplifier and speaker in WeScream! and Sonic Straws. In WeScream! and Sonic Straws, I found the amplified playful sounds appeared to surprise bystanders, facilitating positive interpersonal interactions while people were eating/drinking in a co-location. For example, in the case study of WeScream! players mentioned that the system acted as an icebreaker through the amplified sounds as they attracted the attention of others. The bystanders heard the amplified sounds from the eating spectacle, which evoked curiosity, resulting in them asking questions and ultimately joining in eating together. Similarly, in the case study of Sonic Straws, the amplified sounds surprised bystanders even from remote locations (e.g., one bystander watched a Sonic Straws interaction via a videoconference). This created an opportunity for conversation between bystanders and the player, facilitating more social communications. This is in line with prior work that has shown some people enjoy engaging with audio-visual eating experiences through watching a livestream where a host eats food (e.g. fried chicken wings) with amplified chewing sounds (Anjani et al., 2020; Choe, 2019). These chewing sounds are known as autonomous sensory meridian response elements (Barratt and Davis, 2015) that can evoke pleasurable experiences akin to the flow state (Nakamura and Csikszentmihalyi, 2014). Therefore, I believe that these sounds can play an important role in facilitating positive social eating/drinking experiences. Although the amplified playful sounds can surprise bystanders from afar, I point to the need for the amplified playful sound volume to be below the level of harmful noise.

Overall, I believe that amplified sound has the potential to engage others through its physical reach, inviting bystanders who hear the sound into the experience. This can facilitate social interaction among the people in the same location, inviting them to eat/drink together, thereby contributing to commensality.

7.4.4 Design features for reflection on eating activities beyond the moment

The experiential quality of reflection on eating activities has primarily emerged in the case study of Sonic Straws. I here illustrate two design features to explain the quality: personalisation can give space for reflection and integration of a gustosonic experience into everyday eating/drinking activities can be a source of happiness.

7.4.4.1 Personalisation can give space for reflection

I find that supporting personalisation in gustosonic system design can contribute to reflection. Reflection can help players gain a deeper understanding of their eating/drinking activities in everyday life. According to Fleck and Fitzpatrick (2010), there are five levels of reflection from the lowest R0 to the highest R4. I use these to characterise the different levels of reflection I encountered in my work. In the three case studies, players reported different levels of reflection: these different levels were particularly pertinent in Sonic Straws. This is because I utilised personalisation as a design resource and so I believe that participants were able to customise their playful gustosonic experiences. I explain this now.

The first level of reflection is R0, which refers to a description of events without instruction (Fleck and Fitzpatrick, 2010). In Sonic Straws, this level of reflection came from the fact that players knew they could directly sip the straws to drink water. They could also directly show to others that they could generate playful sounds by drinking via the straws.

The second level of reflection is R1. This refers to reflective description, which means a description including justification or reasons for action or interpretation but in a descriptive way (Fleck and Fitzpatrick, 2010). In Sonic Straws, players described that they were trying to understand why the sounds played back while they were sipping the straws.

The third level of reflection is R2. This refers to a dialogic reflection, which means looking for relationships between pieces of experience or knowledge, evidence of cycles of interpreting and questioning, and consideration of different explanations, hypotheses and other points of view (Fleck and Fitzpatrick, 2010). In Sonic Straws, participants explored the gustosonic system via modifying their drinking patterns. For example, participants tried to perform a beautiful melody by changing sipping pace, mediating the volumes of beverage consumption each time, adjusting the release time while sipping, moving the mouth between two straws, etc. In their reflections on it, they looked for the relationships between these actions and the sounds, and considered different explanations of how their actions resulted in the different sounds they heard or speculated on how the sensor detected their drinking, etc.

The fourth level of reflection is R3: transformative reflection. This refers to revisiting an event with the intent to reorganise it or do something differently (Fleck and Fitzpatrick, 2010). With Sonic Straws, players used their own sound and taste preferences (they could select their own sound files and beverages of choice, although it is acknowledged that water was recommended). This appeared to support the desired self-identity in certain settings, as players utilised sounds to create games that used the beverages as game rewards, sharing intimate information (the taste of the beverage) with their partner through playing the personalised sounds together and using the beverage accompanied by surprising but gentle sounds for comfort. The resulting social interactions were derived from the their reflection on different interpretations around the system. This speaks nicely to the fourth level of reflection, which refers to revisiting an event with the intention to reorganise it or do something differently.

The last level of reflection (R4) is critical reflection, where social and ethical issues are taken into consideration (Fleck and Fitzpatrick, 2010). In the case study of Sonic Straws, I found that players mentioned that drinking accompanied by playful sounds made them reflect on their everyday drinking activities. For example, the players realised that playful sounds could not only be a playful resource, but also affect their drinking activity in everyday life. They enjoyed playful drinking activities accompanied by playful sounds in order to motivate them to drink more frequently and proactively.

7.4.4.2 Integration of a gustosonic experience into everyday eating/drinking activities can be a source of happiness

"Happiness is a consequence of engaging in meaningful activities" (Hassenzahl et al., 2013). According to the authors of this statement, happiness can be facilitated by enriching people's everyday lives with positive experiences through artefact-mediated activities. In my work, I argue that integrating a gustosonic experience into everyday eating activities can offer players positive affect and meaning in order to facilitate happiness. In the three case studies, players reported that they enjoyed the eating/drinking experiences beyond satiation with the food/beverages as they also experienced pleasure associated with playing with sounds. Reframing existing experiences or familiar activities is an efficient way to gain better experiential qualities, in particular when it comes to designing for play (Gaver et al., 1999; Huerga et al., 2016). Through this approach, the novel technological artefact can become more meaningful and experiential, and provide happiness (Hassenzahl et al., 2013). In particular, with Sonic Straws every time the player drank a beverage they could engage with the system, giving rise to the opportunity to naturally experience drinking as play. This study result suggests that the playful drinking experiences emerged not only from a single sip or an episodic drinking experience (e.g. sipping one cup of a beverage) but also from the trajectory of drinking (Benford et al., 2009) through engaging with the playful gustosonic system repeatedly (i.e. the player engaged with Sonic Straws to drink water multiple times over the course of the day). Through engaging with this trajectory, the player could accumulate pleasurable drinking/eating experiences and reflect on their drinking activities through play in everyday life. Moreover, such an integrated experience is in line with the prior theory of unselfconscious interaction (Wakkary et al., 2016), which describes "a form of interaction facilitated by ongoing and incremental intersection with interaction design artifacts that over time and even unknowingly lead to improvements in everyday settings." Sonic Straws appears to confirm this theory by highlighting the potential to facilitate pleasurable effects and experiential improvements. Prior work also suggests that integration of reflection facilitators into everyday life can support self-reflection (Mols et al., 2016a). As such, integrating a playful gustosonic experience into everyday eating/drinking activities offers an opportunity to encourage reflection in an unobtrusive way that can ultimately facilitate happiness.

7.5 Conclusion

In this chapter, I have presented a design framework for playful gustosonic experiences informed by three case studies. I used an iterative approach to identify four key experiential qualities of playful gustosonic experiences: exploration of eating sounds at the initial moment, self-expression via eating actions in the moment, the relatedness of eating together at the shared moment and reflections on everyday eating activities beyond the moment. I revisited the design tactics that were presented through the case studies in order to present eight design features that aim to guide HCI practitioners in the design of future playful gustosonic experiences.

In the next chapter, I will conclude the thesis, discuss limitations and offer ideas for future work.

Chapter 8

Conclusion

THIS chapter summarises the research project, presents the limitations of the work, and proposes future work around designing playful gustosonic experiences. It finishes with a personal conclusion.

8.1 Summary of the research project and scope

Through this thesis study, I have aimed to answer the research question:

How do we design playful gustosonic experiences?

This research project has employed an RtD (Zimmerman et al., 2007) approach to explore the design of playful gustosonic experiences. Gustosonic experiences refer to multisensorial interactions between sounds and the act of eating/drinking (VanCour and Barnett, 2017). Existing studies in the field of experimental psychology highlight that sound plays an important role in our perception of food and drinks. Sounds as a design element also offers meaningful engagement and enjoyment in the field of HCI (see, Ishii, 2004; Kaltenbrunner et al., 2006). However, there is a lack of understanding of how to design interactive technology with sounds to facilitate pleasurable eating/drinking experiences. To begin exploring this, I designed and developed three case studies regarding playful gustosonic experiences. I conducted semi-structured interviews to understand the UX of the playful gustosonic systems. Through grounding the findings of the case studies and my reflections on the design process and design choices, I gained a better understanding of the design of playful gustosonic experiences and generated an initial design framework for playful gustosonic experiences.

All three case studies have contributed to answering my research question and generating the design framework. The first case study, iScream! (Chapter 4), used capacitance sensing to detect eating actions and, based on these eating actions, played four different sounds in real time when participants were licking or biting ice cream. The results from the study were two higher level themes derived from twelve findings which detail how players explored different playful auditory interaction possibilities with their eating actions while the sounds in turn modified those eating actions. Although this case study offered insights towards a design framework for playful gustosonic experiences, it did not provide knowledge about the social aspects of playful gustosonic experiences. This motivated me towards the second case study because engaging with sounds and food can involve social considerations.

Eating together is an important social activity that supports positive interactions (Fischler, 2011). As interactive technology is becoming increasingly common in our lives, interactive technology affects not only how people eat, but also their social interactions within the eating context (Spence et al., 2019a; Niewiadomski et al., 2019). To investigate this, I conducted the second case study, "WeScream!" (Chapter 5). This study extended the design of iScream! to two players. WeScream! went beyond specific pre-selected sounds by allowing players to interact with computer-generated rhythmical sounds produced by eating ice cream collaboratively. The results suggested that the system facilitated playful experiences of "hard fun" through eating together, increased participants' awareness of relatedness and drew shared attention to the ice cream's taste via increased face-to-face interactions.

The results from case study 1 and case study 2 suggested that digitally generated sounds could affect in-the-moment eating experiences via eating ice cream individually or with others. However, ice cream is usually eaten only occasionally and considered a pleasurable treat (Hurling et al., 2015; Linley et al., 2013; Spence et al., 2019b), so I wondered whether the insights gained could also apply to more everyday eating/drinking experiences. Therefore, through case study three, I investigated playful gustosonic experiences beyond one eating/drinking episode, that is, more general everyday eating/drinking activities. Case study three, "Sonic Straws" (Chapter 6), allows players to experience playful personalised sounds via drinking through two straws at the same time. The results suggested that the system supported self-expression via playful drinking actions, facilitated pleasurable social drinking moments and promoted reflections on participants' everyday drinking activities.

Through the findings of the three case studies, coupled with my craft knowledge gained from the design process and related works, I generated a design framework visualised via a 5*4 diagram for designing playful gustosonic experiences. As part of this, I also proposed four key experiential qualities of playful gustosonic experiences: exploration of eating sounds at the initial moment, self-expression via eating actions in the moment, relatedness of eating together at the shared moment and reflections on everyday eating activity beyond the moment.

I hope that this design framework can serve as a design toolkit for designers and HCI practitioners when aiming to designing future playful gustosonic experiences.

8.2 Research contributions

I have made the following contribution with this work:

Artefact contributions

I have designed three playful gustosonic systems: "iScream!", "WeScream!" and "Sonic Straws". These artefacts are playful augmented eating systems combining food materials and digital sounds, supporting playful gustosonic experiences while eating/drinking. The technical details of the implementations could inspire designers to consider designing computational food experiences with interactive technology and practitioners in the hospitality industry to incorporate interactive technology into their practice.

Empirical contributions

This work contributes to empirical knowledge by introducing the UX of the three gustosonic systems. A lab-based study and two in-the-wild studies were conducted to examine the UX. The findings on the UX of three prototypes not only demonstrated the value of playful gustosonic experiences, but also provide design themes for analysing playful gustosonic experiences, as well as practical design tactics that aim to support interaction designers, food designers and creative developers in creating various playful gustosonic experiences.

Theoretical contributions

This work also contributes to theory by presenting a design framework for playful gustosonic experiences. This framework is the first theoretical conceptualisation of how to design playful gustosonic experiences. Through the empirical findings from the three case studies and my craft design knowledge gained from each case study, I have generated a design framework by detailing four key experiential qualities of playful gustosonic experiences for researchers to analyse and eight design features as a tool for HCI practitioners to guide the design of future works.

8.3 Limitations

I acknowledge that my work has limitations, especially around the case studies.

First, I used the RtD (Zimmerman et al., 2007) approach to understand the design of playful gustosonic experiences. I understand that three case studies are not a complete investigation into playful gustosonic experiences. Additional case studies might add more detail to the framework. For example, I used ice cream and beverages (water) as design materials in the playful gustosonic systems. Other food materials could be used to expand the understanding of playful gustosonic experiences in the future.

Second, I acknowledge that my participants in the three case studies reacted to the generated sounds based on their cultural conditioning and natural cognitive experience mapping, especially in Case Study 1. Further exploration of how sound content influences eating/drinking experiences might be needed to gain a complementary understanding of playful gustosonic experiences from a cultural perspective. Longitudinal studies, for example over months in different geographical locations and cultures, might unveil additional insights in terms of understanding the eating experience based on cultural differences. This might benefit from additional insights through the framework.

Third, my recruitment criteria were designed to target a diverse range of participants. Although my work suggests the potential of playful gustosonic experiences to encourage healthy eating/drinking behaviours, this work did not further investigate the impacts on health and wellbeing. I situated this work in understanding the UX of playful gustosonic systems and hence this understanding could benefit and inspire future investigations into how playful gustosonic experiences may benefit users across a range of domains, including those interested in the intersection between food/beverages and health, in particular wellbeing.

Fourth, I acknowledge that this framework could be extended with an enhanced understanding of gustosonic experiences and the advancement of better sensing technologies. For example, future sensing technologies might enable more precise audio feedback while the player is eating or drinking and more powerful microcontroller could be used to support more complex multisensory interactions. The design features of playful gustosonic experiences also do not form a complete list but, rather, can be an initial starting point of reference for designers.

Fifth, I acknowledge that the cultural backgrounds of my participants in the case studies probably impacted on the results in relation to the individual variability of sensory-based studies. Furthermore, the participants' perceptions of sensory cues could have been different due to age differences. I therefore acknowledge that a study containing a larger number of participants with more diverse cultural backgrounds might result in additional understanding of playful gustosonic experiences.

Sixth, the collection of quantitative usage data on Sonic Straws might improve my understanding of the potential applicability of playful gustosonic experiences. For example, a playful beverage-based gustosonic system might have the potential to influence users' drinking behaviour. While sensing technologies are advancing and have become more ubiquitous, computing systems could act with autonomy and become more connected to our emotions and actions. A future gustosonic system might be able to log eating/-drinking data automatically.

Seventh, I acknowledge that the so-called novelty effect could also apply to gustosonic systems, possibly affecting participants' eating/drinking experiences. However, this novelty effect can also be valuable when it comes to facilitating positively anticipated experiences at the initial stage. I also note that this novelty effect of a gustatory innovation has a long culinary history when it comes to multisensory food explorations. For example, alphabet soup appeared 150 years ago and was considered a novelty in 1900, yet it still going strong (Edwards, 2014). To further understand the impact of the novelty effect of the playful gustosonic experience, a longitudinal study could be employed not just at home, but also in commercial dining settings such as restaurants and bars.

8.4 Future work

With the insights gained from the three case studies, I now speculate on future research directions that relate to playful gustosonic experiences.

Exploring playful gustosonic experiences in different domains

I acknowledge that my work was limited by the context and I believe future work could explore different domains, also, for example, designing for healthy eating education. This could involve exploring how a gustosonic system might work with vegetables or fruits to help children engage in eating these foods. Researchers could also create gustosonic systems with specially designed sounds to achieve functional outcomes, such as an augmented mouthfeel via sounds for elderly individuals, serving as an effective vehicle for the delivery of nutrients through sonic cues for people in aged care facilities. Moreover, future work could employ a playful gustosonic experience for food/beverages packaging to improve the customers' eating/drinking experiences. Furthermore, future research could integrate artificial intelligence with gustosonic systems to assess eating behaviours in order to address eating disorders.

Developing related sensing technology for gustosonic experiences

To generate gustosonic experiences, future work might consider various sensing technology; for example, designers could embed advanced capacitance-sensing technology in order to provide more precise sensing data and support different playful gustosonic experiences. Future work could also embed additional sensors (e.g, accelerators, EEG or EMS) to provide more information for creating the playful gustosonic experiences. Moreover, designers could also consider designing novel everyday artefacts that embed a playful gustosonic system in eating/drinking contexts. For example, embedding a playful gustosonic system into a tableware could facilitate social eating experiences. Combining a playful gustosonic system with a smart agents, such as AR eating assistants or eating robots could enrich eating/drinking experiences in everyday life.

Exploring playful gustosonic experiences in longitudinal studies

In this thesis, I propose four experiential qualities of playful gustosonic experiences across different time aspects. These four experiential qualities enable designers to consider designing interactive technology for the different moments of playful eating experiences. However, it is important to note that the playful eating experience can also be characterised as subjective and dynamic. Playful eating reflects an attitude similar to "paidia" in that it is something not serious (Caillois, 2001), but people pursue the mundane activity of eating with pleasure rather than as part of a productive life. To understand the playfulness of gustosonic experience in depth, future work might consider a longitudinal study to understand the UX of playful gustosonic experiences. For example, designers could conduct a repeated testing study over time with weeklong breaks in between to understand how participants experienced incongruent multisensory food experiences through playful eating systems over the longer term.

Designing playful gustosonic experiences in the real world

Food is not only a source of nutrition for survival, but also plays a vital role in enriching our social experiences and expressing cultural features. Prior works suggested that food-related technology has potential to build on contexts, cultures and traditions that can inspire the design of playful food technology (Bertran et al., 2020). Through understanding the UX of three playful gustosonic systems, I found that the demographic of participants suggested interesting future work with different user groups and scenarios. For example, future work could explore how a playful gustosonic system potentially changed eating-disorder behaviours, in particular for female participants. Moreover, a playful gustosonic system could be designed as an interesting icebreaker for building connections between people who do not know each other in a social eating context.

Validating the framework

In this thesis, the design framework for playful gustosonic experiences is derived from my craft knowledge of designing three prototypes. The aim of this design framework is to guide designers and HCI practitioners in the design of playful gustosonic experiences. The next step would be to validate the framework further to identify its utility in different contexts. First, a comparison to other approaches to designing multisensory experiences (e.g. (Obrist et al., 2014a; Amores Fernandez, 2020; Obrist et al., 2014b)) could help in articulating the benefits of the playful gustosonic framework. Second, workshops could be conducted to invite HCI practitioners to engage with the framework, tasking them with the creation of a playful gustosonic experience. Third, end-user evaluations using playful gustosonic systems created with or without use of the framework could be used to validate the framework.

8.5 Final remarks

Through my case studies and the design framework for playful gustosonic experiences, I contribute to design knowledge around how to design playful gustosonic experiences. The design framework has been derived based on an empirical understanding of playful gustosonic experience across different time aspects. The framework comprises four experiential qualities of playful gustosonic experiences: exploration of eating sounds at the initial moment, self-expression via eating actions in the moment, relatedness of eating together at a shared moment and reflections on everyday eating activities beyond the moment. These experiential qualities offer a design space to support designing future multisensory food experiences either in one of these moments or over the whole journey. The design framework could guide food designers who are interested in incorporating digital technology into their practices, interaction designers who aim to create novel playful eating/drinking experiences through sonic interactions, game designers who aim to design novel gameplay around food practices and people from the hospitality industry who want to involve playful experiences into their products.

In this thesis, the three case studies have helped me understand the gustosonic experiences from a playful perspective. This has deepened my understanding of gustosonic experiences and enabled me to reflect on future opportunities when it comes to designing technology to support multisensory integration. As such, I share a design concept named gustosonic experience in HCI. With the presented design tactics for various playful gustosonic experiences and the design framework for playful gustosonic experiences, I contribute to furthering our understanding of technology-mediated playful multisensory experiences and extend the possibility of designing a future multisensory integration with food.

References

Ableton (2021). Music production with live and push — ableton. `https://www.ableton.com/`.

Altarriba Bertran, F., Jhaveri, S., Lutz, R., Isbister, K., and Wilde, D. (2019a). Making sense of human-food interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–13.

Altarriba Bertran, F., Márquez Segura, E., and Isbister, K. (2020). Technology for situated and emergent play: A bridging concept and design agenda. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–14.

Altarriba Bertran, F., Wilde, D., Berezvay, E., and Isbister, K. (2019b). Playful human-food interaction research: State of the art and future directions. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, pages 225–237.

Alves, V. and Roque, L. (2011). Guidelines for sound design in computer games. In *Game sound technology and player interaction: Concepts and developments*, pages 362–383. IGI Global.

Amores Fernandez, J. (2020). *Olfactory interfaces: toward implicit human-computer interaction across the consciousness continuum*. PhD thesis, Massachusetts Institute of Technology.

Anjani, L., Mok, T., Tang, A., Oehlberg, L., and Goh, W. B. (2020). Why do people watch others eat food? An empirical study on the motivations and practices of mukbang viewers. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–13.

Aoyama, K., Sakurai, K., Sakurai, S., Mizukami, M., Maeda, T., and Ando, H. (2017). Galvanic tongue stimulation inhibits five basic tastes induced by aqueous electrolyte solutions. *Frontiers in psychology*, 8:2112.

Arnold, P., Khot, R. A., and Mueller, F. (2018). "you better eat to survive" Exploring cooperative eating in virtual reality games. In *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 398–408.

Arrasvuori, J., Boberg, M., Holopainen, J., Korhonen, H., Lucero, A., and Montola, M. (2011). Applying the PLEX framework in designing for playfulness. In *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces*, pages 1–8.

Arza, E. S., Kurra, H., Khot, R. A., and Mueller, F. (2018). Feed the food monsters! helping co-diners chew their food better with augmented reality. In *Proceedings of the 2018 annual symposium on computer-human interaction in play companion extended abstracts*, pages 391–397.

Audacity (2021). Free,open source, cross-platform audio software. `https://www.audacityteam.org/`.

Back, M. and Des, D. (1996). *Micro-narratives in sound design: Context, character, and caricature in waveform manipulation.* Georgia Institute of Technology.

Baltz, E. (2021). Lickestra – emilie baltz. `http://emiliebaltz.com/experiments/lickestra/`.

Barden, P., Comber, R., Green, D., Jackson, D., Ladha, C., Bartindale, T., Bryan-Kinns, N., Stockman, T., and Olivier, P. (2012). Telematic dinner party: Designing for togetherness through play and performance. In *Proceedings of the Designing Interactive Systems Conference*, pages 38–47.

Barrass, S. (2016). Diagnosing blood pressure with acoustic sonification singing bowls. *International Journal of Human-Computer Studies*, 85:68–71.

Barratt, E. L. and Davis, N. J. (2015). Autonomous sensory meridian response (ASMR): A flow-like mental state. *PeerJ*, 3:e851.

Barzilay, J. I., Weinberg, W. G., and Eley, J. W. (1999). *The water we drink: Water quality and its effects on health.* Rutgers University Press.

Baumer, E. P. (2015). Reflective informatics: conceptual dimensions for designing technologies of reflection. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 585–594.

Bell, G., Blythe, M., and Sengers, P. (2005). Making by making strange: Defamiliarization and the design of domestic technologies. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 12(2):149–173.

Benford, S., Giannachi, G., Koleva, B., and Rodden, T. (2009). From interaction to trajectories: designing coherent journeys through user experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 709–718.

Benford, S., Greenhalgh, C., Giannachi, G., Walker, B., Marshall, J., and Rodden, T. (2012). Uncomfortable interactions. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 2005–2014.

Benford, S., Ramchurn, R., Marshall, J., Wilson, M. L., Pike, M., Martindale, S., Hazzard, A., Greenhalgh, C., Kallionpää, M., Tennent, P., et al. (2020). Contesting control: Journeys through surrender, self-awareness and looseness of control in embodied interaction. *Human–Computer Interaction*, pages 1–29.

Bertran, F. A., Duval, J., Segura, E. M., Vidal, L. T., Chisik, Y., Casulleras, M. J., Pañella, O. G., Isbister, K., and Wilde, D. (2020). Chasing play potentials in food culture: Learning from traditions to inspire future human-food interaction design. In *2020 ACM Conference on Designing Interactive Systems, DIS 2020*, pages 979–991.

Biernacki, P. and Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, 10(2):141–163.

Biggs, L., Juravle, G., and Spence, C. (2016). Haptic exploration of plateware alters the perceived texture and taste of food. *Food Quality and Preference*, 50:129–134.

Blandford, A., Furniss, D., and Makri, S. (2016). Qualitative HCI research: Going behind the scenes. *Synthesis Lectures on Human-centered Informatics*, 9(1):1–115.

Blandford, A. E. (2013). *Semi-structured qualitative studies*. Interaction Design Foundation.

Blasco, R., Marco, Á., Casas, R., Cirujano, D., and Picking, R. (2014). A smart kitchen for ambient assisted living. *Sensors*, 14(1):1629–1653.

Boberg, M., Karapanos, E., Holopainen, J., and Lucero, A. (2015). PLEXQ: Towards a playful experiences questionnaire. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*, pages 381–391.

Boem, A. (2014). Sculpton: A malleable tangible interface for sound sculpting. In *Proceedings of International Computer Music Conference*.

Bogost, I. (2016). *Play anything: The pleasure of limits, the uses of boredom, and the secret of games*. Basic Books.

Braun, V., Clarke, V., Braun, V., and Clarke, V. (2008). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 0887(January):77–101.

Brillat-Savarin, J. A. (1835). Physiologie du goût [The philosopher in the kitchen/The physiology of taste]. *JP Meline: Bruxelles. Translated by A. Lalauze (1884), A handbook of gastronomy. Nimmo & Bain, London, UK.*

Brumby, D. P., Blandford, A., Cox, A. L., Gould, S. J., and Marshall, P. (2016). Research methods for HCI: Understanding people using interactive technologies. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 1028–1031.

Buchenau, M. and Suri, J. F. (2000). Experience prototyping. In *Proceedings of the 3rd conference on designing interactive systems: Processes, practices, methods, and techniques*, pages 424–433.

Burger, K. S. and Stice, E. (2012). Frequent ice cream consumption is associated with reduced striatal response to receipt of an ice cream-based milkshake. *American Journal of Clinical Nutrition*, 95(4):810–817.

Buruk, O., Isbister, K., and Tanenbaum, T. J. (2019). A design framework for playful wearables. In *Proceedings of the 14th International Conference on the Foundations of Digital Games*, pages 1–12.

Caillois, R. (2001). *Man, play, and games*. University of Illinois Press.

Campbell, S. (2004). Dietary reference intakes: Water, potassium, sodium, chloride, and sulfate. *Clinical Nutrition Insight*, 30(6):1–4.

Carvalho, F. M. and Spence, C. (2019). Cup colour influences consumers' expectations and experience on tasting specialty coffee. *Food Quality and Preference*, 75:157–169.

Carvalho, F. R., Steenhaut, K., van Ee, R., Touhafi, A., and Velasco, C. (2016). Sound-enhanced gustatory experiences and technology. In *Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction - MHFI '16*, pages 1–8.

Cespedes-Guevara, J. and Eerola, T. (2018). Music communicates affects, not basic emotions- A constructionist account of attribution of emotional meanings to music. *Frontiers in psychology*, 9:215.

Charness, G., Gneezy, U., and Kuhn, M. A. (2012). Experimental methods: Between-subject and within-subject design. *Journal of Economic Behavior & Organization*, 81(1):1–8.

Cheung, L. and Hanh, T. N. (2010). *Savor: Mindful eating, mindful life*. HarperOne.

Chi, P.-Y. P., Chen, J.-H., Chu, H.-H., and Lo, J.-L. (2008). Enabling calorie-aware cooking in a smart kitchen. In *International conference on persuasive technology*, pages 116–127. Springer.

Chisik, Y., Pons, P., and Jaen, J. (2018). Gastronomy meets ludology: towards a definition of what it means to play with your (digital) food. In *Proceedings of the 2018*

Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts, pages 155–168.

Choe, H. (2019). Eating together multimodally: Collaborative eating in mukbang, a korean livestream of eating. *Language in Society*, 48(2):171–208.

Choi, J. H.-j., Foth, M., and Hearn, G. (2014). *Eat, cook, grow: Mixing human-computer interactions with human-food interactions*. MIT Press.

Coelho, M. (2009). Dinnerware: Why playing with food should be encouraged. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems*, pages 3505–3506.

Corbin, J. and Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

Creswell, J. W. and Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Crisinel, A.-S., Cosser, S., King, S., Jones, R., Petrie, J., and Spence, C. (2012). A bittersweet symphony: systematically modulating the taste of food by changing the sonic properties of the soundtrack playing in the background. *Food Quality and Preference*, 24(1):201–204.

Crisinel, A.-S., Jacquier, C., Deroy, O., and Spence, C. (2013). Composing with crossmodal correspondences: Music and odors in concert. *Chemosensory Perception*, 6(1):45–52.

Cross, N. (1982). Designerly ways of knowing. *Design studies*, 3(4):221–227.

Cycling '74 (2021). Cycling '74. `https://cycling74.com/`.

Dahlbäck, N., Jönsson, A., and Ahrenberg, L. (1993). Wizard of oz studies: Why and how. In *Proceedings of the 1st international conference on Intelligent user interfaces*, pages 193–200.

Dalsgaard, P. and Dindler, C. (2014). Between theory and practice: Bridging concepts in hci research. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 1635–1644.

de Normalisation, O. I. (2010). Iso 9241-210: Ergonomics of human-system interaction-part 210: Human-centered for interactive systems. *International Organization for Standardization*.

Derivative.ca (2018). Derivative TouchDesigner. `http://www.derivative.ca/`.

Derix, E. C. and Leong, T. W. (2019). Towards a probe design framework. In *Proceedings of the 31st Australian Conference on Human-Computer-Interaction*, pages 117–127.

Doehrmann, O. and Naumer, M. J. (2008). Semantics and the multisensory brain: how meaning modulates processes of audio-visual integration. *Brain research*, 1242:136–150.

Donovan, M. M. (2018). Mindful Eating: A Guide to Rediscovering a Healthy and Joyful Relationship With Food. *Journal of Nutrition Education and Behavior*, 50(7):752.

Drever, E. (1995). *Using Semi-Structured Interviews in Small-Scale Research. A Teacher's Guide.* ERIC.

Dubois, D., Guastavino, C., and Raimbault, M. (2006). A cognitive approach to urban soundscapes: Using verbal data to access everyday life auditory categories. *Acta Acustica United with Acustica*, 92(6):865–874.

Edwards, P. (2014). Alphabet soup is 150 years old. This is how we started spelling with our food. `https://triviahappy.com/articles/alphabet-soup-is-150-years-old-this-is-how-we-started-spelling-with-our-food`.

Ekman, I., Ermi, L., Lahti, J., Nummela, J., Lankoski, P., and Mäyrä, F. (2005). Designing sound for a pervasive mobile game. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pages 110–116.

Elder, R. S. and Mohr, G. S. (2016). The crunch effect: Food sound salience as a consumption monitoring cue. *Food Quality and Preference*, 51:39–46.

Ferdous, H. S., Ploderer, B., Davis, H., Vetere, F., and O'hara, K. (2016a). Commensality and the social use of technology during family mealtime. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 23(6):1–26.

Ferdous, H. S., Ploderer, B., Davis, H., Vetere, F., O'Hara, K., Farr-Wharton, G., and Comber, R. (2016b). Tabletalk: Integrating personal devices and content for commensal experiences at the family dinner table. In *Proceedings of the 2016 ACM international joint conference on pervasive and ubiquitous computing*, pages 132–143.

Ferdous, H. S., Vetere, F., Davis, H., Ploderer, B., O'hara, K., Comber, R., and Farr-Wharton, G. (2017). Celebratory technology to orchestrate the sharing of devices and stories during family mealtimes. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 6960–6972.

Ferrara, J. (2012). *Playful design: Creating game experiences in everyday interfaces.* Rosenfeld Media.

Finnegan, D. J., O'Neill, E., and Proulx, M. J. (2016). Compensating for distance compression in audiovisual virtual environments using incongruence. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 200–212.

Fischler, C. (2011). Commensality, society and culture. *Social science information*, 50(3-4):528–548.

Fleck, R. and Fitzpatrick, G. (2010). Reflecting on reflection: Framing a design landscape. In *Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*, pages 216–223.

Fox, R. (2003). Food and eating: an anthropological perspective. *Social Issues Research Centre*, 2003:1–21.

Franinović, K. and Salter, C. (2013). The experience of sonic interaction. *Sonic interaction design: Fresh perspectives*, pages 39–76.

Gajadhar, B. J., De Kort, Y. A., and IJsselsteijn, W. A. (2008). Shared fun is doubled fun: Player enjoyment as a function of social setting. In *International Conference on Fun and Games*, pages 106–117. Springer.

Gaver, B., Dunne, T., and Pacenti, E. (1999). Design: Cultural probes. *Interactions*, 6(1):21–29.

Gaver, W. (2012). What should we expect from research through design? In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 937–946.

Gaver, W., Bowers, J., Boucher, A., Law, A., Pennington, S., and Villar, N. (2006). The history tablecloth: Illuminating domestic activity. In *Proceedings of the 6th conference on Designing Interactive systems*, pages 199–208.

Gaver, W. W., Beaver, J., and Benford, S. (2003). Ambiguity as a resource for design. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 233–240.

Gemici, M. C. and Saxena, A. (2014). Learning haptic representation for manipulating deformable food objects. In *2014 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 638–645.

Gillin, J. L. (1951). *Homo Ludens: A Study of the Play-Element in Culture.* JSTOR.

Global, I. (2021). What is Cultural Background — IGI Global. `https://www.igi-global.com/dictionary/ipad/6367`.

Graham, D. J. and Jeffery, R. W. (2012). Predictors of nutrition label viewing during food purchase decision making: An eye tracking investigation. *Public health nutrition*, 15(2):189–197.

Grimes, A. and Harper, R. (2008). Celebratory technology: new directions for food research in hci. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 467–476.

Gunn, D. P. (1984). Making art strange: a commentary on defamiliarization. *The Georgia Review*, 38(1):25–33.

Hanson-Smith, V., Wimalasuriya, D., and Fortier, A. (2006). Nutristat: Tracking young child nutrition. In *CHI'06 extended abstracts on Human factors in computing systems*, pages 1831–1836.

Harris, J. and Hancock, M. (2019). To asymmetry and beyond! improving social connectedness by increasing designed interdependence in cooperative play. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–12.

Hashimoto, A., Mori, N., Funatomi, T., Yamakata, Y., Kakusho, K., and Minoh, M. (2008). Smart kitchen: A user centric cooking support system. In *Proceedings of IPMU*, volume 8, pages 848–854.

Hashimoto, Y., Nagaya, N., Kojima, M., Miyajima, S., Ohtaki, J., Yamamoto, A., Mitani, T., and Inami, M. (2006). Straw-like user interface: Virtual experience of the sensation of drinking using a straw. In *Proceedings of the 2006 ACM SIGCHI international conference on Advances in computer entertainment technology*, pages 50–es.

Hassenzahl, M., Eckoldt, K., Diefenbach, S., Laschke, M., Len, E., and Kim, J. (2013). Designing moments of meaning and pleasure. experience design and happiness. *International journal of design*, 7(3).

Hassenzahl, M. and Tractinsky, N. (2006). User experience - A research agenda. *Behaviour & information technology*, 25(2):91–97.

Hayashi, S., Ganno, K., Ishii, Y., and Tanaka, I. (2002). Robotic harvesting system for eggplants. *Japan Agricultural Research Quarterly: JARQ*, 36(3):163–168.

Hermann, T., Hunt, A., and Neuhoff, J. G. (2011). *The sonification handbook*. Logos Verlag Berlin.

Heshmat, Y., Neustaedter, C., McCaffrey, K., Odom, W., Wakkary, R., and Yang, Z. (2020). Familystories: Asynchronous audio storytelling for family members across time zones. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–14.

Hicks, J. A. and King, L. A. (2009). Positive mood and social relatedness as information about meaning in life. *The Journal of Positive Psychology*, 4(6):471–482.

Höök, K. and Löwgren, J. (2012). Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 19(3):1–18.

Hornecker, E. (2010). Creative idea exploration within the structure of a guiding framework: The card brainstorming game. In *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction*, pages 101–108.

Houben, M., Brankaert, R., Bakker, S., Kenning, G., Bongers, I., and Eggen, B. (2020). The role of everyday sounds in advanced dementia care. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–14.

Huang, Q., Wang, W., and Zhang, Q. (2017). Your glasses know your diet: Dietary monitoring using electromyography sensors. *IEEE Internet of Things Journal*, 4(3):705–712.

Huerga, R. S., Lade, J., and Mueller, F. (2016). Designing play to support hospitalized children. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*, pages 401–412.

Hurling, R., Linley, P. A., Dovey, H., Maltby, J., and Wilkinson, J. (2015). Everyday happiness: Gifting and eating as everyday activities that influence general positive affect and discrete positive emotions. *International Journal of Wellbeing*, 5(2).

IDEO (2015). *The Field Guide to Human-centered Design: Design Kit*. IDEO.

Isbister, K. (2010). Enabling social play: A framework for design and evaluation. In *Evaluating user experience in games*, pages 11–22. Springer.

Isbister, K., Abe, K., and Karlesky, M. (2017). Interdependent wearables (for play): A strong concept for design. In *CHI*, pages 465–471.

Ishii, H. (2004). Bottles: A transparent interface as a tribute to mark weiser. *IEICE Transactions on information and systems*, 87(6):1299–1311.

Ishikawa, Y., Furudate, Y., and Hoshino, J. (2017). TamaPeeler: An Interactive Cooking Tool for Children's Dietary Education. In *International conference on entertainment computing*, pages 427–430. Springer.

Istrate, D., Castelli, E., Vacher, M., Besacier, L., and Serignat, J.-F. (2006). Information extraction from sound for medical telemonitoring. *IEEE Transactions on Information Technology in Biomedicine*, 10(2):264–274.

Iwata, H., Yano, H., Uemura, T., and Moriya, T. (2004). Food simulator: A haptic interface for biting. In *IEEE Virtual Reality 2004*, pages 51–57.

Jacobi, C., Abascal, L., and Taylor, C. B. (2004). Screening for eating disorders and high-risk behavior: Caution. *International Journal of Eating Disorders*, 36(3):280–295.

Jegers, K. (2007). Pervasive game flow: understanding player enjoyment in pervasive gaming. *Computers in Entertainment (CIE)*, 5(1):9–es.

Jordan, P. W. (2000). *Designing pleasurable products: An introduction to the new human factors*. CRC Press.

Juarascio, A. S., Manasse, S. M., Goldstein, S. P., Forman, E. M., and Butryn, M. L. (2015). Review of smartphone applications for the treatment of eating disorders. *European Eating Disorders Review*, 23(1):1–11.

Kadomura, A., Tsukada, K., and Siio, I. (2014). Educatableware: sound emitting tableware for encouraging dietary education. *Journal of information processing*, 22(2):325–333.

Kaltenbrunner, M., Jorda, S., Geiger, G., and Alonso, M. (2006). The reactable*: A collaborative musical instrument. In *15th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE'06)*, pages 406–411. IEEE.

Kantono, K., Hamid, N., Shepherd, D., Lin, Y. H. T., Yakuncheva, S., Yoo, M. J., Grazioli, G., and Carr, B. T. (2016a). The influence of auditory and visual stimuli on the pleasantness of chocolate gelati. *Food quality and preference*, 53:9–18.

Kantono, K., Hamid, N., Shepherd, D., Yoo, M. J., Carr, B. T., and Grazioli, G. (2016b). The effect of background music on food pleasantness ratings. *Psychology of Music*, 44(5):1111–1125.

Karapanos, E., Zimmerman, J., Forlizzi, J., and Martens, J.-B. (2009). User experience over time: An initial framework. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 729–738.

Khot, R. A., Aggarwal, D., Pennings, R., Hjorth, L., and Mueller, F. F. (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*, pages 6593–6607.

Khot, R. A., Arza, E. S., Kurra, H., and Wang, Y. (2019a). Fobo: Towards designing a robotic companion for solo dining. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–6.

Khot, R. A., Lee, J., Aggarwal, D., Hjorth, L., and Mueller, F. (2015). Tastybeats: Designing palatable representations of physical activity. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 2933–2942.

Khot, R. A., Mueller, F., et al. (2019b). Human-food interaction. *Foundations and Trends® in Human–Computer Interaction*, 12(4):238–415.

Kim, D.-j., Lee, Y., Rho, S., and Lim, Y.-k. (2016). Design opportunities in three stages of relationship development between users and self-tracking devices. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 699–703.

Klemen, J. and Chambers, C. D. (2012). Current perspectives and methods in studying neural mechanisms of multisensory interactions. *Neuroscience & Biobehavioral Reviews*, 36(1):111–133.

Koizumi, N., Tanaka, H., Uema, Y., and Inami, M. (2011). Chewing Jockey. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE '11*, page 1.

Konečni, V. J. (2008). Does music induce emotion? A theoretical and methodological analysis. *Psychology of Aesthetics, Creativity, and the Arts*, 2(2):115.

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., and Wensveen, S. (2011). *Design research through practice: From the lab, field, and showroom.* Elsevier.

Kumar, S. (2021). Pixelate. `http://sureskumar.com/`.

Kwon, H., Jaiswal, S., Benford, S., Seah, S. A., Bennett, P., Koleva, B., and Schnädelbach, H. (2015). Fugaciousfilm: Exploring attentive interaction with ephemeral material. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 1285–1294.

Law, E. L.-C., Roto, V., Hassenzahl, M., Vermeeren, A. P., and Kort, J. (2009). Understanding, scoping and defining user experience: a survey approach. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 719–728.

Lazzaro, N. (2009). Why we play: Affect and the fun of games. *Human-computer interaction: Designing for diverse users and domains*, 155:679–700.

Lemaitre, G., Houix, O., Visell, Y., Franinović, K., Misdariis, N., and Susini, P. (2009). Toward the design and evaluation of continuous sound in tangible interfaces: The spinotron. *International Journal of Human-Computer Studies*, 67(11):976–993.

Leong, J., Wang, Y., Sayah, R., Pappa, S. R., Perteneder, F., and Ishii, H. (2019). Sociabowl: A dynamic table centerpiece to mediate group conversations. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–6.

Lieberman, Z. (2021). Drink up fountain — yesyesno interactive Projects. `http://www.yesyesno.com/drink-up-fountain/`.

Liljedahl, M. (2011). Sound for fantasy and freedom. In *Game sound technology and player interaction: Concepts and developments*, pages 22–43. IGI Global.

Linley, P., Dovey, H., de Bruin, E., Transler, C., Wilkinson, J., Maltby, J., and Hurling, R. (2013). Two simple, brief, naturalistic activities and their impact on positive affect: Feeling grateful and eating ice cream. *Psychology of Well-Being: Theory, Research and Practice*, 3(1):6.

Lionel, T. (2017). *The pursuit of pleasure*. Routledge.

Liu, J., Byrne, D., and Devendorf, L. (2018). Design for collaborative survival: An inquiry into human-fungi relationships. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–13.

Lucero, A., Holopainen, J., Ollila, E., Suomela, R., and Karapanos, E. (2013). The playful experiences framework as a guide for expert evaluation. In *Proceedings of the 6th International Conference on Designing Pleasurable Products and Interfaces*, pages 221–230.

Lucero, A., Karapanos, E., Arrasvuori, J., and Korhonen, H. (2014). Playful or gameful? creating delightful user experiences. *interactions*, 21(3):34–39.

Ludden, G. D., Kudrowitz, B. M., Schifferstein, H. N., and Hekkert, P. (2012). Surprise and humor in product design. *Humor*, 25(3):285–309.

Ludden, G. D. and Schifferstein, H. N. (2007). Effects of visual-auditory incongruity on product expression and surprise. *International Journal of Design*, 1(3).

Macht, M., Meininger, J., and Roth, J. (2005). The pleasures of eating: A qualitative analysis. *Journal of Happiness Studies*, 6(2):137–160.

Márquez Segura, E., Waern, A., Moen, J., and Johansson, C. (2013). The design space of body games: Technological, physical, and social design. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 3365–3374.

Maynes-Aminzade, D. (2005). Edible bits: Seamless interfaces between people, data and food. In *Conference on Human Factors in Computing Systems (CHI'05)-Extended Abstracts*, pages 2207–2210. Citeseer.

McCarthy, J. and Wright, P. (2004). Technology as experience. *interactions*, 11(5):42–43.

McGonigal, J. (2003). A real little game: The performance of belief in pervasive play. *Proceedings of DiGRA 2003*.

McKetta, S. and Rich, M. (2011). The fault, dear viewer, lies not in the screens, but in ourselves: Relationships between screen media and childhood overweight/obesity. *Pediatric Clinics*, 58(6):1493–1508.

Mehta, Y. D., Khot, R. A., Patibanda, R., and Mueller, F. (2018). Arm-a-dine: Towards understanding the design of playful embodied eating experiences. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play*, pages 299–313.

Merter, S. (2017). Synesthetic approach in the design process for enhanced creativity and multisensory experiences. *The Design Journal*, 20(sup1):S4519–S4528.

Mesz, B., Trevisan, M. A., and Sigman, M. (2011). The taste of music. *Perception*, 40(2):209–219.

Micheloni, E., Tramarin, M., Rodà, A., and Chiaravalli, F. (2019). Playing to play: A piano-based user interface for music education video-games. *Multimedia Tools and Applications*, 78(10):13713–13730.

Miller, D., Parecki, A., and Douglas, S. A. (2007). Finger dance: A sound game for blind people. In *Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 253–254.

Milliman, R. E. (1986). The influence of background music on the behaviour of restaurant patrons. *Journal of Consumer Research*, 13(2):286–289.

Mitchell, E. D., Mason, B. S., and Davis, J. E. (1934). The theory of play. *American Journal of Physical Medicine & Rehabilitation*, 13(4):267.

Mitchell, R., Papadimitriou, A., You, Y., and Boer, L. (2015). Really eating together: A kinetic table to synchronise social dining experiences. In *Proceedings of the 6th Augmented Human International Conference*, pages 173–174.

Mols, I., Van den Hoven, E., and Eggen, B. (2016a). Informing design for reflection: An overview of current everyday practices. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*, pages 1–10.

Mols, I., Van Den Hoven, E., and Eggen, B. (2016b). Technologies for everyday life reflection: Illustrating a design space. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 53–61.

Montola, M., Stenros, J., and Waern, A. (2009). *Pervasive games: theory and design.* CRC Press.

Mueller, F., Byrne, R., Andres, J., and Patibanda, R. (2018). Experiencing the body as play. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–13.

Mueller, F. and Isbister, K. (2014). Movement-based game guidelines. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 2191–2200.

Mueller, F., Kari, T., Li, Z., Wang, Y., Mehta, Y. D., Andres, J., Marquez, J., and Patibanda, R. (2020a). Towards designing bodily integrated play. In *Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 207–218.

Mueller, F., Lopes, P., Andres, J., Byrne, R., Semertzidis, N., Li, Z., Knibbe, J., and Greuter, S. (2021). Towards understanding the design of bodily integration. *International journal of human computer studies*, 152:1–25.

Mueller, F., Wang, Y., Li, Z., Kari, T., Arnold, P., Mehta, Y. D., Marquez, J., and Khot, R. A. (2020b). Towards experiencing eating as play. In *Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 239–253.

Mueller, F. F., Gibbs, M. R., Vetere, F., and Edge, D. (2017). Designing for bodily interplay in social exertion games. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 24(3):1–41.

Mueller, F. F., Li, Z., Byrne, R., Mehta, Y. D., Arnold, P., and Kari, T. (2019). A 2nd person social perspective on bodily play. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–14.

Murer, M., Aslan, I., and Tscheligi, M. (2013). LOLL io. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction - TEI '13*, page 299.

Nabil, S., Everitt, A., Sturdee, M., Alexander, J., Bowen, S., Wright, P., and Kirk, D. (2018). Actueating: Designing, studying and exploring actuating decorative artefacts. In *Proceedings of the 2018 Designing Interactive Systems Conference*, pages 327–339.

Nakamura, J. and Csikszentmihalyi, M. (2014). The concept of flow. In *Flow and the foundations of positive psychology*, pages 239–263. Springer.

Narumi, T., Kajinami, T., Nishizaka, S., Tanikawa, T., and Hirose, M. (2011a). Pseudo-gustatory display system based on cross-modal integration of vision, olfaction and gustation. In *2011 IEEE Virtual Reality Conference*, pages 127–130.

Narumi, T., Nishizaka, S., Kajinami, T., Tanikawa, T., and Hirose, M. (2011b). Meta cookie+: an illusion-based gustatory display. In *International Conference on Virtual and Mixed Reality*, pages 260–269. Springer.

Narumi, T., Sato, M., Tanikawa, T., and Hirose, M. (2010). Evaluating cross-sensory perception of superimposing virtual color onto real drink: Toward realization of pseudo-gustatory displays. In *Proceedings of the 1st augmented human international conference*, pages 1–6.

Nawahdah, M. and Inoue, T. (2013). Virtually dining together in time-shifted environment: Kizuna design. In *Proceedings of the 2013 conference on Computer supported cooperative work*, pages 779–788.

Niewiadomski, R., Ceccaldi, E., Huisman, G., Volpe, G., and Mancini, M. (2019). Computational commensality: from theories to computational models for social food preparation and consumption in hci. *Frontiers in Robotics and AI*, 6:119.

Ninomiya, K. (2015). Science of umami taste: adaptation to gastronomic culture. *Flavour*, 4(1):1–5.

North, A. C. (2012). The effect of background music on the taste of wine. *British journal of Psychology*, 103(3):293–301.

NVivo (2021). Qualitative Data Analysis Software — NVivo - QSR International. `https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home`.

Oberfeld, D., Hecht, H., Allendorf, U., and Wickelmaier, F. (2009). Ambient lighting modifies the flavor of wine. *Journal of sensory studies*, 24(6):797–832.

Obrist, M., Comber, R., Subramanian, S., Piqueras-Fiszman, B., Velasco, C., and Spence, C. (2014a). Temporal, affective, and embodied characteristics of taste experiences: A framework for design. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2853–2862.

Obrist, M., Gatti, E., Maggioni, E., Vi, C. T., and Velasco, C. (2017). Multisensory experiences in HCI. *IEEE MultiMedia*, 24(2):9–13.

Obrist, M., Marti, P., Velasco, C., Tu, Y., Narumi, T., and Møller, N. L. H. (2018). The future of computing and food. In *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, pages 1–3.

Obrist, M., Tuch, A. N., and Hornbaek, K. (2014b). Opportunities for odor: experiences with smell and implications for technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2843–2852.

Odom, W., Lindley, S., Pschetz, L., Tsaknaki, V., Vallgårda, A., Wiberg, M., and Yoo, D. (2018). Time, temporality, and slowness: Future directions for design research. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems*, pages 383–386.

Ostuzzi, F., De Couvreur, L., Detand, J., and Saldien, J. (2017). From design for one to open-ended design. Experiments on understanding how to open-up contextual design solutions. *The Design Journal*, 20(sup1):S3873–S3883.

Pohlmeyer, A. E., Hecht, M., and Blessing, L. (2009). User experience lifecycle model continue [continuous user experience]. *Der Mensch im Mittepunkt technischer Systeme. Fortschritt-Berichte VDI Reihe*, 22:314–317.

Polotti, P., Delle Monache, S., Papetti, S., and Rocchesso, D. (2008). Gamelunch: Forging a dining experience through sound. In *CHI'08 extended abstracts on Human factors in computing systems*, pages 2281–2286.

Puckette, M. (2018). Pure data — PD community site. `https://puredata.info/`.

Ranasinghe, N., Cheok, A. D., Fernando, O. N. N., Nii, H., and Gopalakrishnakone, P. (2011). Digital taste: electronic stimulation of taste sensations. In *International Joint Conference on Ambient Intelligence*, pages 345–349. Springer.

Ranasinghe, N., Jain, P., Karwita, S., and Do, E. Y.-L. (2017a). Virtual lemonade: Let's teleport your lemonade! In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction*, pages 183–190.

Ranasinghe, N., Lee, K.-Y., and Do, E. Y.-L. (2014). Funrasa: An interactive drinking platform. In *Proceedings of the 8th international conference on tangible, embedded and embodied interaction*, pages 133–136.

Ranasinghe, N., Nguyen, T. N. T., Liangkun, Y., Lin, L.-Y., Tolley, D., and Do, E. Y.-L. (2017b). Vocktail: A virtual cocktail for pairing digital taste, smell, and color sensations. In *Proceedings of the 25th ACM international conference on Multimedia*, pages 1139–1147.

Rapp, A., Odom, W., Pschetz, L., and Petrelli, D. (2021). Introduction to the special issue on time and hci. *Human–Computer Interaction*, pages 1–14.

Rassinoux, A.-M., Wagner, J. C., Lovis, C., Baud, R. H., Rector, A., and Scherrer, J.-R. (1995). Analysis of medical texts based on a sound medical model. In *Proceedings of the Annual Symposium on Computer Application in Medical Care*, page 27. American Medical Informatics Association.

Razavi, M., Yamauchi, T., Janfaza, V., Leontyev, A., Longmire-Monford, S., and Orr, J. M. (2020). Multimodal-multisensory experiments: Design and implementation. *bioRxiv*.

Reinoso-Carvalho, F., Gunn, L. H., Horst, E. T., and Spence, C. (2020). Blending emotions and cross-modality in sonic seasoning: Towards greater applicability in the design of multisensory food experiences. *Foods*, 9(12):1876.

Reybrouck, M. and Eerola, T. (2017). Music and its inductive power: A psychobiological and evolutionary approach to musical emotions. *Frontiers in Psychology*, 8:494.

Roach, M. (2013). Body: All you can eat. *New Scientist*, 217(2908):42–44.

Roads, C. (2015). *Composing electronic music: a new aesthetic*. OUP Us.

Roballey, T., McGreevy, C., Rongo, R. R., Schwantes, M. L., Steger, P. J., Wininger, M. A., and Gardner, E. B. (1985). The effect of music on eating behavior. *Bulletin of the Psychonomic Society*, 23(3):221–222.

Robson, D. (2002). Play!: Sound toys for non-musicians. *Computer Music Journal*, 26(3):50–61.

Rocchesso, D., Serafin, S., Behrendt, F., Bernardini, N., Bresin, R., Eckel, G., Franinovic, K., Hermann, T., Pauletto, S., Susini, P., et al. (2008). Sonic interaction design: sound, information and experience. In *CHI'08 Extended Abstracts on Human Factors in Computing Systems*, pages 3969–3972.

Roddy, S. and Furlong, D. (2015). Sonification listening: An empirical embodied approach. In *Proceedings of The 21st International Conference on Auditory Display*. Georgia Institute of Technology.

Rogers, Y. (2011). Interaction design gone wild: Striving for wild theory. *interactions*, 18(4):58–62.

Rogers, Y. (2012). Hci theory: Classical, modern, and contemporary. *Synthesis lectures on human-centered informatics*, 5(2):1–129.

Rogers, Y. and Muller, H. (2006). A framework for designing sensor-based interactions to promote exploration and reflection in play. *International Journal of Human-Computer Studies*, 64(1):1–14.

Rogers, Y., Yuill, N., and Marshall, P. (2013). Contrasting lab-based and in-the-wild studies for evaluating multi-user technologies. *The SAGE handbook of digital technology research, SAGE, London*, pages 359–373.

Roto, V. E. (2011). User experience white paper. *UXwhitepaper*.

Rozin, P. (1999). Preadaptation and the puzzles and properties of pleasure. *Well-being: The foundations of hedonic psychology*, pages 109–133.

Ryan, G. W. and Bernard, H. R. (2003). Techniques to identify themes. *Field methods*, 15(1):85–109.

Ryokai, K., Durán López, E., Howell, N., Gillick, J., and Bamman, D. (2018). Capturing, Representing, and Interacting with Laughter. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*, pages 1–12.

Salen, K., Tekinbaş, K. S., and Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. MIT press.

Sanders, E. B.-N. and Stappers, P. J. (2008). Co-creation and the new landscapes of design. *Co-design*, 4(1):5–18.

Schiettecatte, B. and Vanderdonckt, J. (2008). Audiocubes: A distributed cube tangible interface based on interaction range for sound design. In *Proceedings of the 2nd international conference on Tangible and embedded interaction*, pages 3–10.

Segura, E. M. and Isbister, K. (2015). Enabling co-located physical social play: A framework for design and evaluation. In *Game user experience evaluation*, pages 209–238. Springer.

Shankar, M. U., Levitan, C. A., and Spence, C. (2010). Grape expectations: The role of cognitive influences in color–flavor interactions. *Consciousness and cognition*, 19(1):380–390.

Sharp, H. (2003). *Interaction design*. John Wiley & Sons.

Sicart, M. (2014). *Play matters*. MIT Press.

Spence, C. (2011). Crossmodal correspondences: A tutorial review. *Attention, Perception, & Psychophysics*, 73(4):971–995.

Spence, C. (2015a). 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.

Spence, C. (2015b). Sound Bites & Digital Seasoning. *Sound and Interactivity*, 20:9.

Spence, C. (2016). Sound: The forgotten flavor sense. In *Multisensory Flavor Perception*, pages 81–105. Elsevier.

Spence, C. (2017a). Comfort food: A review. *International journal of gastronomy and food science*, 9:105–109.

Spence, C. (2017b). *Gastrophysics: The new science of eating*. Penguin UK.

Spence, C. (2021). Sonic seasoning and other multisensory influences on the coffee drinking experience. *Frontiers in Computer Science*, 3:21.

Spence, C., Mancini, M., and Huisman, G. (2019a). Digital commensality: Eating and drinking in the company of technology. *Frontiers in psychology*, 10:2252.

Spence, C., Navarra, J., and Youssef, J. (2019b). Using ice-cream as an effective vehicle for energy/nutrient delivery in the elderly. *International Journal of Gastronomy and Food Science*, 16:100140.

Spence, C. and Piqueras-Fiszman, B. (2013). Technology at the dining table. *Flavour*, 2(1):1–13.

Spence, C., Reinoso-Carvalho, F., Velasco, C., and Wang, Q. J. (2019c). Extrinsic auditory contributions to food perception & consumer behaviour: An interdisciplinary review. *Multisensory research*, 32(4-5):275–318.

Spence, C., Velasco, C., Vanne, M., and Hopia, A. (2014). Can you taste the music. *5D cookbook. Seinäjoki: KUMURU-project*, page 73.

Spence, C. and Wang, Q. (2015a). Wine and music (I): On the crossmodal matching of wine and music. *Flavour*, 4(1):33.

Spence, C. and Wang, Q. (2015b). Wine and music (II): Can you taste the music? Modulating the experience of wine through music and sound. *Flavour*, 4(1):33.

Stummerer, S. and Hablesreiter, M. (2009). *Food design XL*. Ambra Verlag.

Suits, B. (1984). Games and utopia: Posthumous reflections. *Simulation & Games*, 15(1):5–24.

Sung, J., Grinter, R. E., and Christensen, H. I. (2009). "Pimp my roomba": Designing for personalization. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 193–196.

Suzuki, C., Narumi, T., Tanikawa, T., and Hirose, M. (2014). Affecting Tumbler: Affecting our flavor perception with thermaldback. In *Proceedings of the 11th Conference on Advances in Computer Entertainment Technology*, pages 1–10.

The Fat Duck (2021). The Fat Duck. `http://www.thefatduck.co.uk/`.

Tolmie, P., Benford, S., and Rouncefield, M. (2013). Playing in Irish music sessions. *Ethnomethodology at play*, pages 227–256.

Tu, Y., Yang, Z., and Ma, C. (2015). Touching tastes: The haptic perception transfer of liquid food packaging materials. *Food Quality and Preference*, 39:124–130.

Vaismoradi, M., Jones, J., Turunen, H., and Snelgrove, S. (2016). Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice*, 6(5):6–7.

van den Bosch, K. A., Andringa, T. C., Peterson, W., Ruijssenaars, W. A., and Vlaskamp, C. (2017). A comparison of natural and non-natural soundscapes on people with severe or profound intellectual and multiple disabilities. *Journal of Intellectual & Developmental Disability*, 42(3):301–307.

Van Henten, E., Van Tuijl, B. v., Hemming, J., Kornet, J., Bontsema, J., and Van Os, E. (2003). Field test of an autonomous cucumber picking robot. *Biosystems engineering*, 86(3):305–313.

VanCour, S. and Barnett, K. (2017). Eat what you hear: Gustasonic discourses and the material culture of commercial sound recording. *Journal of Material Culture*, 22(1):93–109.

Vandevelde, C., Conradie, P., De Ville, J., and Saldien, J. (2014). Playful interaction: Designing and evaluating a tangible rhythmic musical interface. In *INTER-FACE: The Second International Conference on Live Interfaces*, pages 1–7.

Vegetableorchestra (2007). The vegetable orchestra. `http://www.youtube.com/watch?v=hpfYt7vRHuY{&}feature=youtube{_}gdata`.

Velasco, C., Carvalho, F. R., Petit, O., and Nijholt, A. (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*, pages 1–7.

Velasco, C., Karunanayaka, K., and Nijholt, A. (2018). Multisensory human-food interaction. *Frontiers in psychology*, 9:796.

Wakkary, R., Desjardins, A., and Hauser, S. (2016). Unselfconscious interaction: A conceptual construct. *Interacting with Computers*, 28(4):501–520.

Walla, P., Richter, M., Färber, S., Leodolter, U., and Bauer, H. (2010). Food-evoked changes in humans. *Journal of Psychophysiology*, 24(1):25–32.

Wang, Q. J., Spence, C., and Knoeferle, K. (2020). Timing is everything: Onset timing moderates the crossmodal influence of background sound on taste perception. *Journal of Experimental Psychology: Human Perception and Performance*.

Wang, Y., Li, Z., Jarvis, R., Khot, R. A., and Mueller, F. (2018). The singing carrot: Designing playful experiences with food sounds. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, pages 669–676.

Wang, Y., Li, Z., Jarvis, R. S., Russo, A., Khot, R. A., and Mueller, F. (2019). Towards understanding the design of playful gustosonic experiences with ice cream. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, pages 239–251.

Watson, Q. J. and Gunther, K. L. (2017). Trombones elicit bitter more strongly than do clarinets: A partial replication of three studies of crisinel and spence. *Multisensory research*, 30(3-5):321–335.

Wei, J., Cheok, A. D., Martinez, X. R., Tache, R., Choi, Y., Koh, J. T. K. V., Peiris, R. L., Wang, X., and Zhu, Q. (2011a). FoodGenie: Play with your food edible interface for communication and entertainment. In *SIGGRAPH Asia 2011 Emerging Technologies*, pages 1–1.

Wei, J., Wang, X., Peiris, R., and Choi, Y. (2011b). CoDine: An interactive multi-sensory system for remote dining. *Ubicomp 2011: Ubiquitious Computing*, pages 21–30.

Wilde, D. (2011). Extending body and imagination: moving to move. *International Journal on Disability and Human Development*, 10(1):31–36.

Wilde, D. and Bertran, F. A. (2019). Participatory research through gastronomy design: a designerly move towards more playful gastronomy. *International Journal of Food Design*, 4(1):3–37.

Wrigley, C., Gomez, R., and Popovic, V. (2010). The evaluation of qualitative methods selection in the field of design and emotion. In *Proceedings of the 7th International Conference on Design and Emotion 2010*, pages 1–12.

Wu, Y. and Bryan-Kinns, N. (2017). Supporting non-musicians? creative engagement with musical interfaces. In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition*, pages 275–286.

Yu, L. and Kang, J. (2010). Factors influencing the sound preference in urban open spaces. *Applied Acoustics*, 71(7):622–633.

Zampini, M. and Spence, C. (2004). The role of auditory cues in modulating the perceived crispness and staleness of potato chips. *Journal of Sensory Studies*, 19(5):347–363.

Zimmerman, J., Forlizzi, J., and Evenson, S. (2007). Research through design as a method for interaction design research in HCI. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 493–502.

Zimmerman, J., Stolterman, E., and Forlizzi, J. (2010). An analysis and critique of research through design: Towards a formalization of a research approach. In *proceedings of the 8th ACM conference on designing interactive systems*, pages 310–319.

Ziv, N. (2018). Musical flavor: The effect of background music and presentation order on taste. *European Journal of Marketing*.

Zoran, A. and Cohen, D. (2018). Digital konditorei: Programmable taste structures using a modular mold. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–9.

Appendix

Ethic approval letters.

Case study one ethics approval letter

RMIT UNIVERSITY

College Human Ethics Advisory Network (CHEAN)
College of Design and Social Context
NH&MRC Code: EC00237

Notice of Approval

Date:	**21 August 2018**
Project number:	**CHEAN A 21633-07/18**
Project title:	**'Exploring Playful Experiences with Food Sounds'**
Risk classification:	**Low risk**
Chief investigator:	**Professor Florian Mueller**
Status:	**Approved**
Approval period:	From: **21 August 2018** To: **25 August 2019**

The following documents have been reviewed and approved:

Title	Version	Date
Risk Assessment and Application Form	2	8 August 2018
Participant Information Sheet and Consent Form	3	21 August 2018
Interview Questions	2	8 August 2018
PLEX Questionnaire	2	8 August 2018
Recruitment Email	2	8 August 2018
List of Ingredients	1	21 August 2018
Response to CHEAN	1	21 August 2018

The above application has been approved by the RMIT University CHEAN as it meets the requirements of the *National Statement on Ethical Conduct in Human Research* (NH&MRC, 2007).

Terms of approval:

1. **Responsibilities of chief investigator**
   It is the responsibility of the above chief investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by CHEAN. Approval is valid only whilst the chief investigator holds a position at RMIT University.
2. **Amendments**
   Approval must be sought from CHEAN to amend any aspect of a project. To apply for an amendment use the request for amendment form, which is available on the HREC website and submitted to the CHEAN secretary. Amendments must not be implemented without first gaining approval from CHEAN.
3. **Adverse events**
   You should notify the CHEAN immediately (within 24 hours) of any serious or unanticipated adverse effects of their research on participants, and unforeseen events that might affect the ethical acceptability of the project.
4. **Annual reports**
   Continued approval of this project is dependent on the submission of an annual report. Annual reports must be submitted by the anniversary of approval of the project for each full year of the project. If the project is of less than 12 months duration then a final report only is required.
5. **Final report**
   A final report must be provided within six months of the end of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.
6. **Monitoring**
   Projects may be subject to an audit or any other form of monitoring by the CHEAN at any time.

K:\R and I\Research Office\Human Ethics_RM\HE_DSC\2018 Applications\21633 - F Mueller\CHEAN A 21633-07-18, Prof F Mueller - Notice of Human Research Ethics Approval.doc

7. **Retention and storage of data**
   The investigator is responsible for the storage and retention of original data according to the requirements of the *Australian Code for the Responsible Conduct of Research* (section 2) and relevant RMIT policies.
8. **Special conditions of approval**
   Nil.

In any future correspondence please quote the project number and project title above.

Dr Marsha Berry
Chairperson, College Human Ethics Advisory Network (CHEAN B)
RMIT University

Dr Scott Mayson
Deputy Chairperson, College Human Ethics Advisory Network (CHEAN A)
RMIT University

cc: Dr David Blades (CHEAN secretary), Ms Yan Wang, Dr Rohit Ashok Khot.

Case study two ethics approval letter

RMIT UNIVERSITY

College Human Ethics Advisory Network (CHEAN)
College of Design and Social Context (DSC)
NHMRC Code: EC00237

Notice of Approval

Date:	**17 June 2019**
Project number:	**CHEAN A 21633-07/18**
Project title:	**'Exploring Playful Experiences with Food Sounds.'**
Risk classification:	**Low Risk**
Investigator(s):	**Professor Florian Mueller, Ms Yan Wang, Dr Rohit Ashok Khot**
Approval period:	From: **17 June 2019** To: **25 April 2020**

I am pleased to advise that your amendment and extension request has been granted ethics approval by the Design and Social Context College Human Ethics Advisory Network (DSC CHEAN), as a sub-committee of the RMIT Human Research Ethics Committee (HREC). The CHEAN approves:

- The additional phase of data collection involving a one-week study of user experience, PLEX questionnaire, interviews and diary;
- Amended PISCF, interview topics, and recruitment material; and
- Extension of ethics approval until 25 April 2020.

Terms of approval:

1. **Responsibilities of investigator**
   It is the responsibility of the above investigator/s to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by the CHEAN. Approval is only valid whilst the investigator/s holds a position at RMIT University.
2. **Amendments**
   Approval must be sought from the CHEAN to amend any aspect of a project including approved documents. To apply for an amendment please use the 'Request for Amendment Form' that is available on the RMIT website. Amendments must not be implemented without first gaining approval from CHEAN.
3. **Adverse events**
   You should notify HREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
4. **Participant Information Sheet and Consent Form (PISCF)**
   The PISCF and any other material used to recruit and inform participants of the project must include the RMIT university logo. The PISCF must contain a complaints clause.
5. **Annual reports**
   Continued approval of this project is dependent on the submission of an annual report. This form can be located online on the human research ethics web page on the RMIT website.
6. **Final report**
   A final report must be provided at the conclusion of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.
7. **Monitoring**
   Projects may be subject to an audit or any other form of monitoring by HREC at any time.
8. **Retention and storage of data**
   The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Please quote the project number and project title in any future correspondence.

On behalf of the DSC College Human Ethics Advisory Network, I wish you well in your research.

Dr David Blades
DSC CHEAN Secretary
RMIT University
dscethics@rmit.edu.au

Case study three ethics approval letter

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project ID: 24232
Project Title: Understanding the design of playful drinking system with sounds
Chief Investigator: Professor Floyd Mueller
Approval Date: 06/07/2020
Expiry Date: 06/07/2025

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MUHREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible for the storage and retention of the original data pertaining to the project for a minimum period of five years.

Kind Regards,

Professor Nip Thomson

Chair, MUHREC

CC: Dr Rohit Khot

List of approved documents:

Document Type	File Name	Date	Version
Consent Form	Consent Form	10/06/2020	1
Supporting Documentation	Interview Questions	11/06/2020	1
Supporting Documentation	Interview Topics	11/06/2020	1
Supporting Documentation	Drinking in the wild_Poster	11/06/2020	1
Supporting Documentation	Invitation Mail	11/06/2020	1
Explanatory Statement	Explanatory Statement	11/06/2020	1

Page 1 of 1