Towards Understanding the Design of Playful Gustosonic Experiences with Ice Cream

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ABSTRACT
There is an increasing trend that explores the convergence of digital play and eating to support a playful relationship with food. We note that interactive sound, although prevalent in digital game design, has only received limited attention in this trend. To contribute to an understanding of "playful gustosonic experiences", we present a design and study of a novel capacitive-sensing ice cream cone, "*iScream!*". In a study with 32 participants, the cone played four different sounds (a roaring, crunchy, giggling, and burping sound in order to explore fantasy facilitation, food congruency, anthropomorphism and bodily response) when eating ice cream. The results are two themes derived from six findings each, which detail how players explored the different auditory interaction possibilities with their eating actions while the sounds in turn modified those eating actions. Based on these findings, we present four design tactics for designers aiming to create playful gustosonic experiences to ultimately facilitate a more playful relationship with food.

Author Keywords
Food sounds; Food Play; Human-Food Interaction; Gustosonic experiences

CCS Concepts
•**Human-centered computing** → **Ubiquitous and mobile computing design and evaluation methods;** *Interaction design;*

INTRODUCTION
Food not only satisfies our hunger, but its consumption also offers a rich multi-sensory enjoyable experience [59]. In fact, eating has been described as "life's most enjoyable experience" [9]. However, we note that many works in the field of Human-Food Interaction (HFI) seem to treat food only as an energy source [16, 23], for example see the systems that aim to reduce snacking, promote making the right food selection or balance nutrition [44, 48, 73]. This is one perspective on food, however, with our project we take on the aforementioned perspective of eating being a multi-sensory enjoyable experience [59], in particular, we highlight the playful aspects of eating through the use of interactive sound. In doing so we aim to support a more playful relationship with food. We answer the previous call [23] to develop more "celebratory technologies", (i.e. technologies that support positive aspects of people's interactions with food) to support enjoyable eating experiences. Similarly, we answer to the call [14] for more "gastroludical" experiences, which are defined as involving physical sensations associated with eating combined with digital technology to create enjoyable eating experiences. Such alternative perspectives on food interactions are able to contribute solutions to address some of today's pressing issues surrounding food such as eating disorders, food waste and mindless eating [41]. Furthermore, we answer the call [6] to further playfulness in gastronomy, as this is believed to enable chefs to provide new dining experiences. Finally, we respond to the call [71] to connect playfulness facilitated by

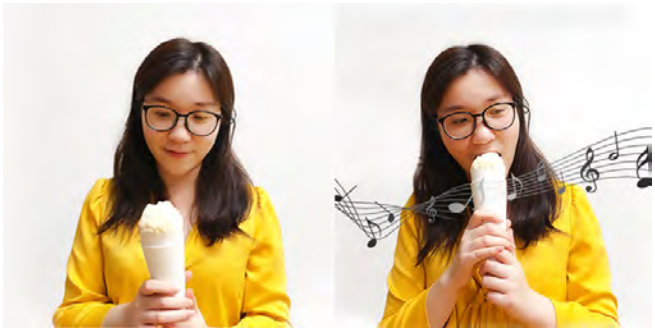

Figure 1. *iScream!* is a novel capacitive sensing ice cream cone that plays different sounds when licking the ice cream

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interactive technology with active participation in eating experiences. Guided by these calls, we subscribe to the view that exploring the convergence of digital play and eating can result in playful eating experiences, which can ultimately result in a more positive relationship with food.

Prior interactive systems around playful eating experiences have explored food's smell, taste, texture [49, 43, 30, 33] as wells as processes of creating and sharing food [39]. Although sound is prevalent in digital game design, we find that interactive sound in the convergence of digital play and eating has only received limited attention, probably because sound is perceived as a less important sense when it comes to experiencing food [55]. However, prior research in experimental psychology on food and dining experiences demonstrate that sound plays a far more pivotal role in dining because our perception of taste is profoundly affected by sound [11, 57, 74]. For instance, we perceive the freshness of potato chips by the quality of the "crunch" sound, hence if we hear crunchier sounds, chips are perceived to be fresher and more palatable [74]. Our eating behaviour is also influenced by sound, for example, fast-paced background music can increase people's eating speed and also facilitate taking more bites [40]. Moreover, studies showed that sound also influences our perception of taste, for example, sweetness can be suppressed by a loud noise [59], while taste of umami can be enhanced with a loud background noise [45]. Many restaurants also use sound as an "extra ingredient" to facilitate rich dining experiences. For example, the dish "Sound of the Sea" [62] encourages diners to listen to the sound of sea waves through headphones while they eat a seafood dish. Inspired by these works, we believe that sound could facilitate playful eating experiences through altering or supporting our perception of food [18, 69]. Our goal is to support people's innate desire for play by facilitating playful eating experiences through the use of interactive sounds.

Figure 2. The 3D-printed *iScream!* cone.

To contribute towards a design understanding of "playful gustosonic experiences", we present a novel capacitive-sensing ice cream cone we call *iScream!* (Figure 1, 2). It generates unique sounds based on licking actions. "Gustosonic" refers to links between the act of eating and listening within a combined multisensory experience [64]. The user is free to perform any eating action, for instance, biting or licking the ice cream, which results in a variation of sounds. We can program *iScream!* to play any sound (like a "scream", hence the name *iScream!*) and it works with any off-the-shelf ice cream. Our sensing system also works with other foods, for example we have successfully experimented with carrots [70], cucumbers, apples and pears. However, we begin our investigation into gustosonic experiences with ice cream as it seems to align well with our focus on playfulness, as studies have shown that ice cream can increase pleasure and positive emotions while contributing to happiness and well-being [26, 67].

We conducted a study with 32 participants. We set up the cone to produce four different sounds, a roaring, crunchy, giggling, and burping sound. We began our selection of the sounds for the study by examining play theory and in particular we were inspired by the dimensions of the playful experiences framework (PLEX) [37]. We selected four of these dimensions based on what we believed were suitable and practical for interactive eating experiences and refined the actual sound development through playtesting, i.e. eating a lot of ice cream. The final sounds were a "roaring sound" (aligned with "stimulation experiences" of the PLEX framework), "crunchy sound" ("pragmatic experiences"), "giggling sound" ("momentary experiences") and "burping sound" ("negative experiences"). These sound selections allowed us to explore fantasy facilitation, food congruency, anthropomorphism and bodily response respectively, which we explain further below.

Interviews with participants resulted in two themes that were derived from six findings each. These themes detail how players explored the different auditory interaction possibilities with their eating actions while the sounds in turn modified those eating actions. This interplay between eating action and sound generation could potentially facilitate experiencing eating as play [41], a notion we derive from prior theory [42] suggesting that players could experience their body (including eating) as play rather than using their body to play. This aligns with our intention of designing eating experiences that are playful rather than using food as a mere input controller for play, i.e. as a toy.

Our research makes the following contributions: 1) Through presenting *iScream!*, we highlight to the HFI community how generating sounds can facilitate a playful gustosonic experience. 2) We present the design details of a capacitive-sensing ice cream cone called *iScream!*, aiding designers interested in developing interactive sound around eating. 3) We contribute the first conceptual design understanding of the interrelationship between eating and interactive sounds by presenting the results from a study of experiencing *iScream!*. 4) We also present four design tactics for designers aiming to create playful gustosonic experiences. Ultimately, we aim to facilitate a more playful relationship with food.

RELATED WORKS

In this next section, we detail what we have learned from prior work around play, sound and eating.

Playful interaction with food

Most of us probably remember times when our parents told us not to play with food. However, playing with food constitutes a great part of our childhood. Playing lies in our human nature, it is one of the ways to explore our relationship with objects, the environment and ourselves, which includes food and eating [5, 53]. Supporting these playful food interactions using digital means is not new. For example, LOLLio [43] combines interactive technology with a lollipop to dynamically change flavours as a way to offer a playful eating experience. Polotti et al. designed a sonically augmented dining table called Gamelunch [47] that allows people to experience continuous sound feedback while having lunch. "Straw-like User Interface" [24] is a virtual drinking system that replicates the sucking sound associated with drinking through a straw. Arnold et al. [1] developed a game that uses chewing noises detected by a sensor attached to the face as a game controller to enrich a virtual reality experience. Arza et al. [2] designed an augmented reality game using sound delivered through a head-mounted display to motivate proper chewing techniques. These works have contributed to enriching the food experience through sound, however, these and others tend to do one of two things: either they focus on augmenting the perception of food texture, thus enhancing the multisensory aspect of eating or they use sound as a game interface. Therefore, knowledge about the design of playful gustosonic experiences remains limited. We also note that many of these previous works require additional sensors attached to the user's face, an intervention which we believe has the potential to negatively affect the user experience. In contrast, we want to facilitate a playful eating experience and aim for a system with minimal setup requirements. Existing projects most similar to our work are "Chewing Jockey" [31] and "Lickestra" [3]. Chewing Jockey is a technical investigation into the detection of jaw movement (through a photoreflector attached to the face), where the system plays sounds through headphones while the user chews. The premise of Chewing Jockey is that playing fantasy sounds while chewing gummy sweets could provide users with playful eating experiences. Lickestra by artist Baltz is a musical performance [3] where the user licks ice cream to play an instrument. We were inspired by the playfulness of these works and decided to begin our investigations with ice cream and draw on the fantasy element when selecting our sounds (see below). Together with our design approach, we complement these prior technical and artistic works with a structured analysis of the resulting user experience to determine whether interactive sound can playfully enrich the eating experience.

Sound in relation to eating

Sound that certain foods make during eating through chewing, biting or licking play an essential role in our perception of food. People described lettuce and crisps as crispy whereas raw carrots, peanuts and almonds are typically described as crunchy [55]. Although sound has been described as the forgotten sense in the eating experience [58], research on the relationship between sound and eating has emerged in recent years [19, 66, 68, 63]. For example, crunchy chewing sound could influence the perception of food texture even if the actual food texture is soft [22]. Music has been shown to influence the mood while dining, and this, in turn, can affect taste perception and eating behaviours [29]. Red wine is perceived as tasting heavier when powerful music is played compared to no background music [46]. Similarly, sweetness is increased with high pitch sounds [60]. Perception of bitterness is increased with low pitch sounds [17]. Ninomiya et al. concluded that umami is like a bass note in music [45]. Spence et al. proposed that loudness of sounds could match the sweetness of wine [60]. Furthermore, jazz music has been shown to increase the overall pleasantness of chocolate [28]. Overall, these works suggest that food sounds have the potential to affect our food perception and could potentially contribute to a playful eating experience.

ISCREAM!

To contribute towards a design understanding of "playful gustosonic experiences", we present a novel capacitive-sensing ice cream cone called *iScream!*. The *iScream!* system dynamically generates digital sounds when the player eats ice cream. We 3D-printed a plastic ice cream cone, which hosts the hardware (Figure 3). 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 a custom-made *Touch Designer program* [20] via Open Sound Control (OSC), which then generates the sounds played back through speakers. In the future, we are planning on embedding the speaker inside the cone. The sensed capacitance value varies depending on the amount and the position of the ice cream in the 3D-printed cone.

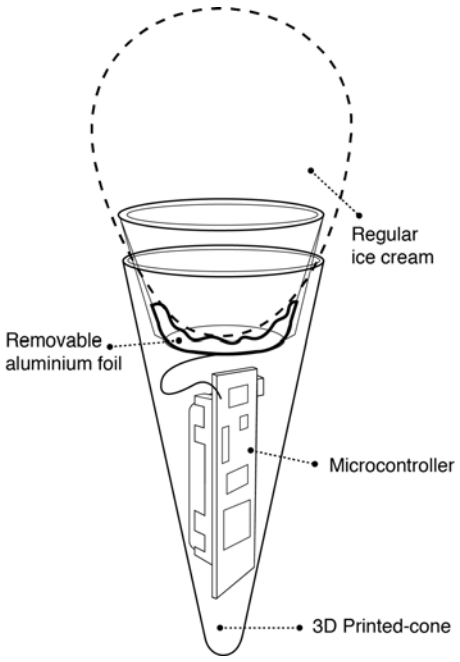

Figure 3. The 3D-printed cone contains a wireless microcontroller connected to removable food-safe aluminium foil that then makes contact with the ice cream.

iScream! interactions

Several approaches exist in the literature to sense eating actions. For example, "EducaTableware" [27] includes a sensing fork with an integrated three-electrode conductive probe that detects between two tines of a 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" [15]. It utilizes 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, we designed a wireless ice cream cone that uses Wi-Fi as we found the Bluetooth signal to be less reliable because the signals are subject to a wide variety of interference. Both resistance and capacitance could sense food as food has conductivity attribute. However, we found that capacitance offered us more reliable data than resistance while eating physical food without any utensils [70].

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. We normalize the capacitance value within the interval of 0.0 to 1.0 in Touch Designer. The sound is triggered when the capacitance value is above a 0.65 threshold. This threshold value was identified after 20 trails with different eating patterns during design prototyping. We worked with sound designers from our university to banks of 10 variations of each sound. We began by selecting 60 second sound clips that we edited in the Audacity software, breaking each one of them down into 10 smaller clips. We found that biting or licking ice cream is normally around 0.5 to 0.9 seconds long. First, we used 1-second clips in our initial investigation; the result showed that users needed more time to react to what they have heard. After two more rounds of iterations, we shortened each clip to 3 seconds with a 1 second fade-out. When the player performs a lick-on and lick-off action the system randomly triggers one of the edited variations of the current sound-bank (Figure 4). If the player keeps biting or licking the ice cream without release, the sound continuously plays in a loop. The process stops after the ice cream is completely eaten.

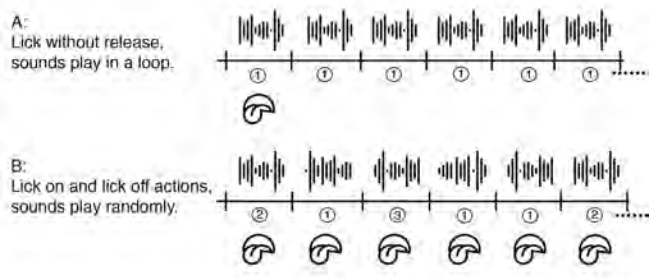

Figure 4. Sound interactions

DESIGN PROCESS

iScream! was the result of many explorations, extensive prototyping and iterative design. We conducted three brainstorming sessions and group discussions to help refine our design choices and to gather diverse insights on how to sense eating actions and how to select the sounds. The brainstorming sessions included ten experts with diverse academic backgrounds that included two industry designers, two sound designers, two game designers, one electrical engineer and three interaction designers (2 from HCI and 1 from HFI). The aim of the first brainstorming session was to identify different possible interaction patterns and decide on the technical feasibility, i.e., identifying the right hardware and tools for the system. We discussed different ways to sense eating actions (e.g., motion tracking, wearable tracking devices). Finally, we settled on capacitance sensing as it seemed the least intrusive method of detection. Two sound designers helped us in creating a library of possible sounds. For the first iteration, we also selected a few food items that include 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 [37] and envisioned interaction. These brainstorming sessions involved initial playtesting, where we mapped different food items to different sounds and asked participants' preferences for each and why. We settled on ice cream, as it offered a more positive experience of eating than other food items. We also reduced the sound library to 16 and further refined it to 4 based on the PLEX framework [37].

Selecting the sound categories

iScream! can be programmed to play any sound. However, we opted to play four different sounds based on four categories as it allowed us to explore a range while fitting in the duration it takes to eat a regular 1-scoop ice cream portion. We were inspired by Wilde et al. [72], 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, we aimed to create an engaging playful experience.

Based on our collective craft knowledge of sounds, we selected a set of 16 playful sounds from an open-source sound library. We conducted a 2-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 of possible manipulations of digital sound but also their feasibility related to current sensing technologies. We also discussed sound variables such as duration, frequency, intensity [50] and thought about detailed sound qualities, such as a higher pitched giggle or a deeper chuckle. Finally, we chose 10 sounds from the set of 16 playful sounds.

Then, we conducted a small study with seven users (between 20 to 50 years) to examine the tactile experience of holding our prototype and performing eating actions with each of the 10 sounds. Participants verified our design choices and could imagine using *iScream!* in scenarios such as outdoors, at a

party, at home, and in a restaurant. We finally narrowed down the categories of sounds related to four dimensions of playfulness [37], (stimulation, pragmatic, momentary and negative experiences) as suggested by Boberg et al. [7]. After 70 trials in total, we were able to develop the final set of sounds. We believe that the resulting roaring, crunchy, giggling, and burping sound would allow us to explore fantasy facilitation, food congruency, anthropomorphisation and bodily response, see below. We acknowledge that this list of sounds is not exhaustive and further exploration might lead to more categories; we also add that different sounds within a category could also be considered and implemented with our system easily.

Roaring sound: The first playful sound is a roaring sound similar to that of a lion in an animated movie, which we 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 [37]. Prior work found that transiting players into a fantasy world can generate intrigue and curiosity while facilitating positive emotions [32]. We hoped players would transit into a fantasy world and feel curios about discovering new eating experiences. Furthermore, we note that a similar kind of fantasy sound was used in the Chewing Jockey system [31], which strengthened our belief that this might be an intriguing sound category to explore.

Crunchy sound: With the "crunchy sound", we wondered how the ice cream experience would change if, instead of hearing the licking sound of ice cream, a congruent sound, we 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 [58, 59].

Giggling sound: The playful sound of "giggling" was inspired by the "momentary experience" grouping of playfulness, referring to "captivation", "humour" and "relaxation" categories of PLEX. Momentary playfulness experiences are associated with temporal pleasurable states where people laugh and release stress [52]. Drawing inspiration from this, we chose a high pitched giggling sound to add humour [52]. We 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: We chose the "burping sound" because we 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. 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 [4].

ISCREAM! IN ACTION

We conducted a study with 32 participants (13 male, 19 female), where we used a within-subject design, meaning that each player experienced all four sounds in a randomized manner. The participant recruitment followed a snowballing method and there was no financial compensation. The players' ages were between 18-50 years (M=26, SD=4.3). We conducted a pre-study interview, where we asked players about any food allergies and preference 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. We used a common off-the-shelf vanilla ice cream.

We set up the volume at 75db, which is well below the level of harmful noise and also allowed participants to alter the volume if needed. We asked the participants to eat the ice cream as they would normally do. We started with one scoop for each participant. The participant was free to ask for a refill and they could stop eating at any time. Before we started our study, we told the participants that we had four sounds in random order. Participants could ask the researcher to change the sound at any time. The eating part of the study took 20 minutes per participant on average. Then players took part in a semi-structured interview that lasted between 45 minutes to 1 hour. We asked questions related to the effects of sounds, expectations, utility and experiences of engaging with *iScream!*. We 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 using Microsoft Excel. Three independent coders followed the process of the inductive thematic analysis [8]. Each question and the associated answer represented one unit of data resulting in 781 data units in total. We examined 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 was then used to group them together. We iteratively clustered related labels into higher-level groupings. Any difference in the results was further refined and discussed between three coders. In the first iteration of the thematic analysis we developed 82 codes, for example "Understanding playful experiences of food sounds", and "Changing eating actions". Then we discussed the 82 codes and re-examined them to merge similar codes together in order to reduce the complexity. Through this process we reduced the number of codes to 22. Those remaining codes were refined, re-examined and categorized into groups with the help of two senior researchers. The final outcome of these analytic and evaluative processes is depicted in figure 5 that includes two overarching themes, which we present next.

FINDINGS

Overall, our players found *iScream!* very engaging and commented that the system was able to facilitate a playful experience, accompanying their own laughter. Our analysis resulted in two themes that detail how players explored the different auditory interaction possibilities with their eating actions while

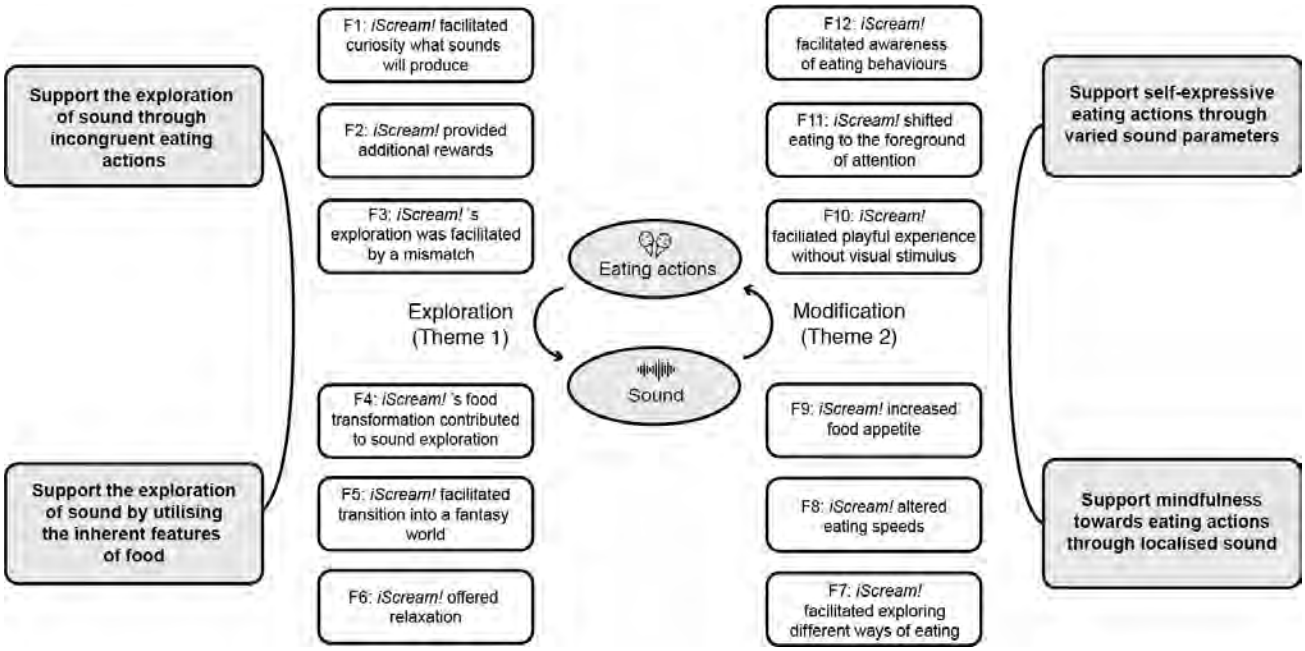

Figure 5. Our implications for design (grey background) based on our findings (labelled with F) highlighting the ongoing loop between eating actions exploring sounds and sounds modifying eating actions

the sounds in turn modified those eating actions. Aspects of the design facilitated an iteration between exploration and modification, which we explain below. We then use this to articulate four design tactics for designers aiming to create playful gustosonic experiences.

Theme 1: Eating actions facilitated the exploration of sound

This theme describes how the eating actions facilitated the exploration of sound. In particular, we identified the following findings (F) to be important: F1-sound curiosity through eating; F2-eating reward through sound; F3-sound exploration through sound-eating mismatch; F4-food transformation contributing to sound exploration; F5-transition into a fantasy world; F6-eating sound offering relaxation.

F1: iScream! facilitated curiosity what sounds eating will 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 appeared to facilitate a sense of curiosity of how the ice cream will sound next 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 allows me to focus on: 'How can I play sounds through eating and what kind of sounds would come out?'"* Similarly, P23 mentioned, *"It puts you through a thought process about what is next? Then, it arose my curiosity, which sort of sounds would be played next? You are also having fun as sounds keep on changing. It's 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 act as a reward to play with ice cream. I got enjoyment from both eating and playing with it."* This was considered contributing to the playful character of the experience, even with the burping sounds. One participant 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 and what it sounded like. Participants found that mismatch intriguing and in response explored the sounds further. For example, P11 laughed and described, *"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 am playing crunchy sound tracks while I am 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

an ongoing transformation of the food, i.e. the ice cream was melting. For example, one of the participants said, *"The ice cream was constantly changing shape as it was melting and the sound associated with it was varying too."* P10 described 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 [ice cream dripping on finger] but to allow exploring the sounds."*

F5: iScream! facilitated transition into a fantasy world

Fifteen participants enjoyed the roaring sound as it appeared to transition them into a fantasy world. The study happened during a Spring/early Summer season, however, the roaring sound reminded players of instances when they ate 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 am 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 transitioned them into. For example, P19 said, *"I liked how ice cream adds another layer to music composition, definitely, a new form of interaction, when I heard the roaring sound, it seems like I was walking in the field hiding somewhere and observing fierce animals. I felt exciting 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 are the creatures that live in the snow."*

F6: iScream! offered relaxation

Twenty participants felt hearing positive sounds (i.e. laughing sound, crunchy sound, 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 sounds, and this makes eating more enjoyable."* P6 added, *"I think eating is relaxation and sounds like wind blowing sounds [roaring sounds] make me feel very relaxed. I like the sounds with some rhythm; it will take me to enjoy the imagination of eating ice cream. It is enhancing my eating experience beyond taste, by bringing in the aspect of sounds."*

Theme 2: Sounds facilitated the modification of eating

This theme describes how sounds modified players' eating actions. We identified the following findings (F) in relation to this: F7-sounds facilitating exploration of eating; F8-sounds altering eating speeds; F9-sounds increasing food appetite; F10-sounds facilitated playful experiences without visual stimulus; F11-sounds shifting eating to the foreground, and F12-sounds facilitating awareness of eating behaviours.

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 touching with fingers. P10 said, *"I wanted to see for 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 plays 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 is like eating chips, but actually I am 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 way, I was able to relate roaring to mouth opening."*

F8: iScream! altered eating speeds

Six participants reported that their eating speeds was altered by sounds. P30 mentioned, *"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 is interesting to change my eating speeds by playing with these sounds. I like 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 food. Ice cream is typically consumed without sonic-textural 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 experience without visual stimulus

iScream! did not offer any additional visual stimulus while eating. Fifteen participants mentioned that they used to eat 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 are 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 made 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 behaviours

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 notice that sounds could influence my eating behaviours."* P17 also said, *"It made me realize 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."*

IMPLICATIONS FOR DESIGN

Our findings appear to confirm the theory by Mueller et al. [42] that players could experience their body as play (including eating) by shifting the focus between the body (the fleshy body as object) and lived body (the felt body as experienced) back and forth. For example, the player first tries to put the ice cream into his/her mouth using his/her body to consume food. Then he/she perceives playful sound through their eating actions. After that the player explores sounds though eating actions, and the player's attention shifts to their eating actions to better control the sound. Therefore, we suggest that designers can learn from experiential design knowledge to facilitate an interplay between eating actions and sounds, as this appears to have potential to support experiencing eating as play.

In the following section, we reflect on our findings in detail and discuss them in relation to prior work. Together with our craft knowledge gained from designing *iScream!*, we use this to present four design tactics relating to the two themes. We hope that with the four tactics we provide designers with practical guidance when aiming to create playful gustosonic experiences.

Support the exploration of sound through incongruent eating actions

Our brain connects information from multisensory input [54, 56], while the sensory information usually corresponds to the same semantic identity [25, 66]. In addition, we relate information based on the compatibility of crossmodal correspondences [17, 66]. For example, we sense the sound of chewing chips and attribute that to the sound of a fast food restaurant (semantic correspondence). Moreover, when we hear the crunchy sounds of chips, the sound may guide our expectations about the quality of the chips (crossmodal correspondence). The congruent experiences occur when our perception equals expectation. If people feel something different than expected, surprise occurs. Prior work suggests that designing appropriate incongruences can evoke surprise and humour to support playful experiences [38]. In our study, before participants started eating, they see the regular ice cream and correspond that to soft and creamy (crossmodal correspondence). Then the congruence between multisensory experiences (i.e., the taste, tactile experience, melting over time) and the expectation of ice cream is confirmed once people start eating. However, when participants perceive an incongruent sound from the ice cream that differs to what they expect, they experience surprise, resulting in a playful eating experience.

iScream! engaged with incongruency 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 incongruency, in particular evident through the transition to a fantasy world, where the fantasy is incongruent with the physical world the participants experience 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 [35]. Fantasy facilitation is a common design strategy in game design to support playful experiences [32]. We therefore confirm the theory [13] that sound can bring images about a setting, extending it to interactive food sound, and argue that it can be used to support incongruency to facilitate a playful experience. For example, we selected a roaring sound in *iScream!*, however, many participants thought of it as a cold breezing wind sound, which appeared to transition 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. We found it intriguing that the selection of sounds could facilitate fantasy elements around food, which then in turn supported an incongruency that facilitated a playful experience.

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

Support the exploration of sound by utilising the inherent features of food

Prior work suggests that the inherent features of food (i.e., colour, scent, texture and taste [61]) could be used as design material to support playful experiences. For example, Arnold

et al. [1] 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 [65] that utilised the vegetable's inherent sounds to perform contemporary music. Designers have also looked into conductive properties of food to support play. For example, the public drinking facility called "Drink Up Fountain" [34] 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. designed LOLLio [43] that 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 eat the ice cream, i.e. 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 the ice cream, 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 the ways 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 how the ice cream sounds when touching with their hand, when ice cream would be running over their fingers, etc. This messiness appeared to contribute to the playful character of the experience [30].

We recommend to designers to 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 a playful eating experience.

Support self-expressive eating actions through varied sound parameters

Our study indicated 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, here we extend this to the generation of sounds as a way to support the modification of eating actions [50], in particular we randomized these parameters. For example, in our 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 when the high-pitched giggle coincided with an eating action. Since we randomised the sound clips of each sound source as mentioned earlier, participants dynamically altered their eating speed and the ways 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, we also found that participants explored opening and closing their mouth as a way to map the roaring sound source. 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 that it is controlled), designers can support the modification of eating actions. We 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 suggests to change sound parameters to modify eating actions, for example see the work on music in restaurants that showed that fast tempo music can increase the number of bites per minute in diners [51]. With our work, we 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, we can facilitate playful eating experiences. As such, we recommend to designers to support the modification of eating actions through varied sound parameters. In particular, we highlight the potential of engaging with the control of these parameters in order to support self-expression as a way to facilitate playful eating experiences.

Support mindfulness towards eating actions through localised sound

We found that the extrinsic sounds supported the modification of eating actions. The exploration of sounds appeared to have shifted 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 sounds, 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 is and what it reminds them of. With respect to the giggling sounds, participants wanted to experiment whether their eating has 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, we can say that the extrinsic sound resulted in supporting mindfulness of eating actions. We might have noted that such a shifting of attention is not inherently playful, nevertheless, we believe it is supportive to 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 additional visual stimulus. This is especially noteworthy as 15 participants said that they usually eat ice cream in front of a TV, mobile phone or computer. It is commonly believed that screens can distract from the experience of eating and that this has a negative impact, leading to eating disorders and obesity [10].

With this in mind, we can see instances emerging of using sound-based play to support mindful eating practices. Mindful eating [21, 12] is a 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. Our study suggests that playful gustosonic experiences like *iScream!* have the potential to support mindful eating practices as it can facilitate a shift of attention towards the food and make participants 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, we recommend to designers to support mindfulness towards eating actions through localised sounds as a way to support a playful eating experience.

LIMITATION AND FUTURE WORK

We acknowledge that our work has several limitations. Firstly, we only explored one kind of food in our study, the investigation of additional food might enrich our findings further, which is possible thanks to our universal sensing system. Secondly, we acknowledge that the selection of sounds was limited. We understand our work not as a complete investigation into playful gustosonic experiences, but rather that this work could serve as a springboard for future explorations. In the future, we may also use various ice cream flavours, explore how sounds influence participant's perception of each flavour, add more sound categories and explore additional melodies for playful gustosonic experiences. We also acknowledge that our study was done in a lab environment, eating ice cream in different contexts and environments might reveal more findings. For future study, an in-the-wild approach might reveal additional insights. Lastly, we consider novelty as an intriguing element of playful eating experiences and therefore propose that our work offers a valuable starting point for future investigations. Nevertheless, despite these limitations, we believe that our work provides first useful insights into the design of playful gustosonic experiences that could inform the design of future systems aiming to support playful eating experiences.

CONCLUSION

In this paper, we described the design and study of *iScream!*, a novel playful gustosonic experience with ice cream. There is a trend in human-food interaction to explore the intersection between eating and digital play, however, the use of sound is relatively underexplored. Through our work, we focus on the use of interactive sound to facilitate a playful eating experience, in particular, we began by exploring interactive sound when eating ice cream. Hedonic indulgences like ice cream provide people with enjoyment, satisfying both psychological and physiological needs that necessities may not meet [37]. Consequently, people pursue opportunities that allow them to consume such "mood foods" that are usually highly desirable [10, 36]. However, in doing so, they often overindulge, consuming more calories than what they should typically consume. A solution to such practice could be through education, moderation or restriction, but such solutions have shown to be a limited success in the long run [21]. Although there has been previous work in the area of human-food interaction (HFI) that celebrates the positive relationships people have with food, most do not involve a sound-based approach. A playful solution like the one explored through *iScream!* could be helpful to aid designers in experimenting with sound parameters in order to draw attention to the pleasure derived from eating.

With our work, we hope we are able to guide designers who are interested in designing playful experiences involving food and sounds. Ultimately, we aim to contribute to a deeper understanding of the design of playful eating experiences.

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