Towards Experiencing Eating as Play

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ABSTRACT

There is an increasing trend in HCI to combine eating and technology. We highlight the potential of interactive technology to support an experiential perspective on eating, in particular, how interactive technology can support experiencing eating as play. To understanding this, we reflect on four playful interactive eating systems we designed and two other works to articulate five strategies: make eating challenging, break cultural norms, design across eating stages, reduce eating autonomy, and playfully extend the social aspect. For each, we also include practical implementation options to provide designers with initial guidance on how they can begin to support experiencing eating as play. Ultimately, with our work, we aim to facilitate a future where eating is more playful.

CCS CONCEPTS

• Human-centered computing → Interaction design

KEYWORDS

Food; Eating; Human-Food Interaction; FoodCHI; Play

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1 Introduction

The field of human-food interaction (HFI) has been steadily growing over the years, producing interesting systems that combine interactive technology with eating (e.g. [5,11,26,31,49,65,66,67,85,89,90]). Many of these HFI works focus on the instrumental perspective of food-technology interactions, such as health benefits. Prominent examples include mobile apps that help people manage their nutritional intake (e.g. [57]). In contrast, we see the potential of technology to support the experiential and in particular playful side of the eating experience. We are inspired by prior bodily play research that argued to "experience the body as play" rather than using the body as a mere game controller [86]. Similarly, we believe that food-technology interaction is not just another way to replenish energy, but rather a way to "provide nourishment for the soul as well as the body" [15]. As such, we regard our work as not replacing but complementing prior HFI work and see the merging of eating and technology as a unique opportunity to *experience eating as play.*

We propose that when people experience eating as play they approach the eating activity with an attitude similar to that of "paidia", as something not serious [87]. Similarly, Suits [74] stresses the importance of a "lusory attitude" when it comes to play, which we can also see being drawn upon when it comes to eating. A stark contrast would be eating to avoid starvation. This contrast highlights that supporting playful eating needs to carefully balance nutritional intake and play. We extend prior work around play and eating [15] by presenting practical design knowledge from our craft and how this could be implemented in future design practice.

Understanding how to design eating as play not only satisfies our innate desire to play but might also facilitate positive benefits [84], including enriched social interactions [5,25] and food appreciation [73]. Moreover, we believe such a design understanding could also be a starting point towards mindful eating. This trend supports people in developing a healthy approach to eating by emphasizing the benefits of an "enjoyable" relationship with food [14]. Furthermore, as research in HFI has previously identified that the games community has been pioneering in pushing the HFI field forward [28,53], we believe the HCI community interested in multimodal

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interactions might also benefit from this work. We acknowledge that our approach comes from a privileged perspective where eating can be much more than just nourishment. Overall, we believe an increased design understanding on how to support experiencing eating as play can ultimately contribute positively to our engagement with food.

In the next section, we present related work and what we learned from it, before describing a set of playful eating systems from ourselves and others. We use these playful eating systems to articulate five design strategies in the form of intermediate design knowledge [33]. These strategies are aimed to guide designers who want to support users experiencing eating as play. We acknowledge that these strategies are not comprehensive, however, we believe they can be beneficial for game designers, food technology developers, interaction design practitioners and even chefs who aim to venture into the intersection of technology and food and apply their expertise there. In summary, we hope to begin constructing a more structured design understanding of how to create interactive technology systems to support experiencing eating as play. We believe this will lead to our ultimate aim of facilitating a future where eating is more playful.

2 Related Work

Prior work in HFI highlighted the positive role interactive technology can play in food-related practices including cooking, cultivating, eating and disposing [16]. Many of these works focus on the instrumental perspective of food-technology interactions [91] including nutritional intake [45,59], healthy eating [62] and sustainable food practices [17]. In contrast, we build on the fact that food is much more than a source of energy. Food has a rich cultural and social history, with its consumption providing opportunities for bonding and interactions among people [30,43,88]. French gastronome Brillat-Savarin [13] notes that eating and drinking constitute some of life's most enjoyable experiences. Food technology can thus be regarded as a celebratory one [30], going beyond satisfying hunger. Drawing on this, the experiential and in particular playful side of eating has recently begun to gain currency within HFI [12,53,73,82,92,93]. In our previous work in progress at CHI PLAY we have already discussed three systems in regards to eating as a form of play [53]. Here we extend this prior work by clarifying what we mean by eating as play, discussing more systems and implications for design, making a deeper and enriched contribution. Also at CHI PLAY, Chisik et al. [15] provided a theoretical overview and described how playful eating predates technology use, which we draw upon. We believe that the tangible and embodied interaction community should be as invested into the topic as the CHI PLAY community due to eating's tangible and embodied nature, hence we use this article to introduce TEI to the idea of experiencing eating as play. Next, we describe some key works and articulate what we have learned from them.

2.1 Interactive Technologies Around Eating

It is commonly believed that technology use during eating should be avoided as it distracts from eating [72]. Aiming to alter this common perception, several projects have emerged to demonstrate the positive impact technology can have as part of eating. We focus on those concerned with eating and production (i.e. cooking), as they seem to be most prevalent in the literature while often being discussed in the community. Furthermore, they can most directly affect the end user and therefore fit nicely with our focus on the user experience of eating. For instance, Ferdous et al. [25] suggested that existing technologies such as mobile phones can be repurposed to facilitate shared activities that lead to positive experiences of eating together. Similarly, Davis et al. [18] revealed how digital technologies can create social interactions at the family dinner table thus prolonging the meal. "CoDine" [81] is another example of the positive use of technology, allowing remote diners to eat "together" by networking projectors mounted above distributed dining tables.

Besides these academic works, we also see industry using interactive technology to offer playful eating experiences (Spence's book "Gastrophysics" [73] offers an initial overview). For example, in the "Inamo" restaurant [34], projectors display playful animations on dining tables to give an impression of the food coming to life. The "Sound of the Sea" dish [75] transforms the seafood dining experience through an ocean soundscape delivered through headphones [44]. Furthermore, in the "Etxanobe" restaurant [24] Virtual Reality headsets have been used to augment the dessert experience. These works teach us that interactive technology can support the experiential aspects of eating. However, a structured understanding of how to design such interactions appears to be still missing.

Researchers have also explored how interface technologies can enhance dining. "TasteScreen" allows users to lick liquid residue of different flavors that drips onto the LCD screen [47,69]. Ranasinghe et al. [65] developed "Taste/IP" to share taste over the internet by

combining electrical and thermal stimulation of the tongue. The same team also developed a "Digital Flavor Synthesizing" device that uses perfumes as a supplement for their digitally created flavors [67]. Ranasinghe et al. [66] also developed "Spoon+" and "Bottle+" prototypes to virtually manipulate the taste of drinks and foods. Similarly, "Nourished" artificially stimulates all senses without a caloric intake [60]. Using these works as examples, we focus on the experiential aspects to provide an understanding of how to facilitate experiencing eating as play.

With advancements in 3D-food printing technology, attempts have also been made to facilitate new food experiences. For example, Wei et al. [80] created a food-based messaging system using a food printer. Fukuchi et al. [26] invented laser cooking that uses a laser cutter and image processing techniques to cook food according to the shape and composition of ingredients, allowing for new tastes and textures to emerge. "Qkies" [70] is a system that embeds QR codes onto cookies, while "Meta Cookie+" [58] controls nutritional intake by increasing the perceived size of a cookie via an augmented reality head-mounted display. From these works, we learn that emerging technologies can offer novel ways to engage with food, and we draw from this in our articulation of how to engage with such technologies to support experiencing eating as play.

In summary, prior work has pointed towards the potential of interactive technology to support not just instrumental but also experiential aspects of eating. However, not much conceptual understanding exists on how to design interactive technology to facilitate experiencing eating as play. To begin building such a design understanding, we present an initial set of strategies, complemented with implementation options, based on existing systems that we hope can aid designers in their practice.

3 Playful Eating Systems

We now present six existing playful eating systems: Four of these systems we designed, developed, exhibited and studied ourselves, while two are from related work. All of our own four works include a study that is detailed in the related paper, we refer to these studies and associated user experiences throughout the strategies. We chose our four systems as we have intimate knowledge about their design, their implementation (we have developed all components ourselves, including hard- and software) and through the associated studies how they facilitate experiencing eating as play. This allows us to provide a first-hand account, including insights into the opportunities and challenges working with food within a design research lab. We complement these systems with two from prior work as we want to show the wide range of possibilities that exist for designers today. We selected these particular systems as they appear to be well cited, have received media attention, have been described as "landmark examples" [28] and seem to be often referred to in our HFI workshops, suggesting that readers might be familiar with them (e.g. [37,88]). Although we have not tried them out ourselves, we believe they complement our systems, and we hope that their inclusion instills confidence that our strategies can hold true not just for our practice but also for others', hence adding validity to the claim that the strategies can be useful for other designers. Having external examples also enables us to discuss the design strategies around technologies we have not explored ourselves, strengthening the utility argument of our contribution. We also lean on portfolio design research that has previously argued for the benefit of discussing a set of examples to highlight a wide range of design possibilities [27]. Furthermore, we build on a similar number of examples that have previously been used in HCI to derive design strategies [6]. With our approach, we hope we can paint a picture of the design of experiencing eating as play that is abstract yet close to design practice.

3.1 Arm-A-Dine

Arm-A-Dine is a two-player interactive playful eating experience (Fig. 1) [19]. Each participant wears a robotic arm, attached to a vest, which acts as a wearer's third arm for feeding. The scenario is a casual eating experience standing up. With the robotic arm attached to a vest worn by the body, participants need to move their bodies to align the arm's gripper with the food on a table. Once the arm picks up a particular food item, it feeds it to either the wearer or his/her partner. The wearer's arm performs actions based on the partner's facial expressions captured by a camera attached to the wearer's vest. If the partner makes a "sad" expression, the arm will feed the wearer. If the partner expresses "happiness", the arm will feed the partner. However, if the system senses neither a particular positive or negative expression, the arm will move back and forth, teasing both participants with not revealing who will be fed next before making a random choice. Arm-A-Dine was designed to explore playful eating interactions by focusing on the feeding action from the plate to the mouth while considering the strong affinity eating has with emotions. A study [19] suggested that

Arm-A-Dine participants experienced a playful social eating experience which was accompanied by much laughter.

Figure 1: Arm-A-Dine participants feeding each other using on-body robotic arms

3.2 You Better Eat to Survive!

Figure 2: The non-VR player feeds food to the VR player as he cannot see the food

"You Better Eat to Survive!" (YBEtS!) [4,94] is a two-player Virtual Reality (VR) game involving food (Fig. 2). One player puts on a VR headset and tries to send an SOS message after being stranded on an island. The scenario is that the player has not eaten for days and is on the brink of losing consciousness and passing out. The loss of vision is referred to as blackout phase and represented using a steadily shrinking view simulating lack of consciousness (Fig. 3).

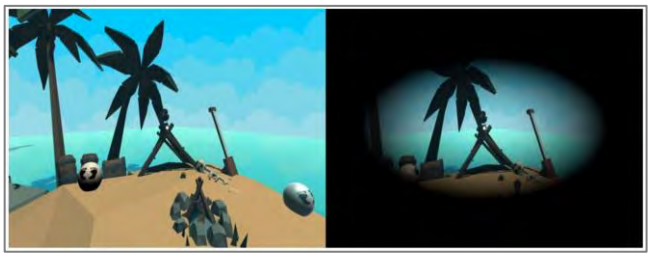

Figure 3: Transition of vision during a blackout phase

The objective of the game is to move around the island and scavenging through different objects, eventually finding a flare gun. Once found, the player fires it to call for help and wins the game. If a blackout phase starts, the only way to regain vision is by eating real food. The eating activity is detected using a microphone attached to the player's cheek. As the microphone detects chewing, the player's vision increasingly restores until there is full vision again.

The challenge for the VR player is that he/she cannot see the food while wearing the VR headset (Fig. 2). The food is on three tables set up as a triangle around the players, resembling the playing field. The task of the second player is to guide the player with the VR headset around the playing field to the food and then feed him/her. This creates a setup where one player is in the virtual world while the other remains in the real world. This setting enforces both players to play as one "shared body" across both worlds. The VR player cannot see the food but sees the virtual world, while the other player does not see the virtual world but sees the food. Physically, the players resemble one body because the physical world player embraces the VR player from behind and uses his/her own hands as it would be the VR player's hands to feed him/her, while the VR player is disallowed to use his/her hands (Fig. 2). In order to win, the players need to cooperate. While the VR player tries to discover a way to get help in the game, the physical world player is in charge of feeding him/her to prevent losing vision in the game. This game aims to facilitate a rich social experience around VR through experiencing eating as play.

3.3 EdiPulse

EdiPulse [36] 3D-prints chocolate representations of heart rate data from physical activity in forms of cheerful messages, emoticons and treats (Fig. 4). Examples include a smiling emoticon or a message like "Well done!" printed in chocolate congratulating an individual on a successful completion of an activity. The form and thickness of the chocolate print correlates to the duration and intensity of

the physical activity performed by the user and measured via a heart rate monitor. The chocolate is received regardless of whether or not a significant amount of physical activity is performed. The system aims to offer a playful representation of one's activity in edible form. A study [36] revealed how such a playful culinary rendering of bodily data could inspire individuals towards achieving their fitness-related goals as well as facilitate social interactions around being physically active and eating in families.

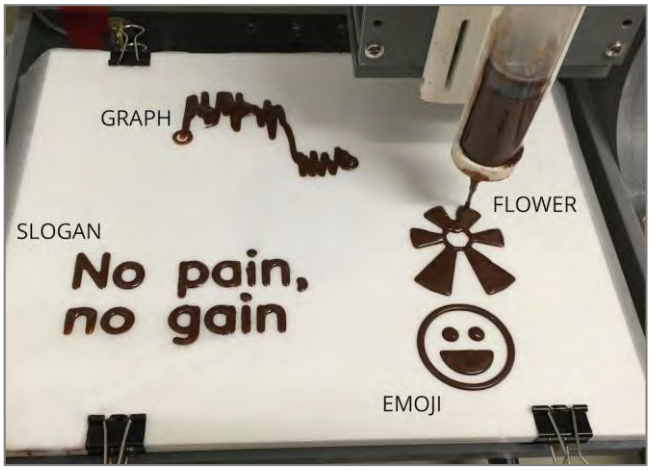

Figure 4: The EdiPulse chocolate printer prints playful representations of a participant's physical activity

3.4 TastyBeats

TastyBeats [38] uses a fountain-inspired setup to create a cocktail mix of different sports drink ingredients based on a user's heart rate data measured from physical activity (Fig. 5). The system includes a glass in the center and four containers each with a water pump underneath. TastyBeats reads the user's heart rate data and then drives the water pumps from the corresponding containers. The pumps shoot the liquid from the containers into the central glass. This performative element was inspired by the way bartenders mix drinks in front of bar patrons. TastyBeats reads the user's heart rate data and then drives the water pumps from the corresponding containers. If the user's heart rate value is between 60 and 95 beats per minute, the system drives the pump that serves water; if the heart rate value is between 96 and 130, lightly flavored water will be chosen; if the heart rate value is between 131 and 165, liquid containing electrolytes will be chosen, and if the heart rate value is between 166 and 195, richly flavored water will be added to the central glass. The user can later consume the cocktail, replenishing the loss of bodily fluids as a result of the physical activity. A study [38] highlighted that the mixing and drinking of sports drinks was playful and refreshing after a physically strenuous activity.

Figure 5: TastyBeats' water pumps shoot the drink's liquid into the central glass

3.5 LOLLio

LOLLio [51,56] is an interactive lollipop that dynamically changes its taste. The system consists of two parts, a small handheld device and a spherical lollipop at the end of a plastic stick. During the interaction with the device, small amounts of a sour liquid (thinned citric acid) are pumped from the grip to an outlet on the candy. By using a high concentration of the sour substance and varying the rate of flow, different tastes in the sour-sweet interval can be achieved. LOLLio is both an input and output device: wireless connectivity to a laptop allows for remote triggering of the taste while motion sensing with accelerometers at the end of the stick allows for using it as an input modality. The authors describe potential games [56] that are controlled by the movement of the lollipop, and output informed by varying the amount of thinned citric acid that is injected through the hole in the candy.

3.6 Chewing Jockey

Chewing Jockey [40] is a playful system that uses chewing sounds to enrich the eating experience without modifying the physical texture of the food. The chewing actions are augmented using a bone-conducting speaker that delivers a filtered sound or sound effects to the user: a microphone records the chewing sound and a photo-reflector measures the movement of the jaw. The goal is to change the perceived texture of the food through playing augmented sound effects based on the chewing action. One of the playful implementation scenarios involves using gummi sweets so that when chewing, the user hears "screaming" sounds, making the sweets feel like "living creatures".

4 Design Strategies to Facilitate Experiencing Eating as Play Design

We now describe five strategies derived from examining the examples above. We also use the examples to highlight the different ways of how the strategies could be implemented, resulting in implementation options that we present at the beginning of each strategy as a bullet point list. Of course, each list does not articulate all options, nor do we say that implementing these options will guarantee results. However, we believe that providing these options could guide designers who do not know where to start. The strategies emerged from our practice of designing, exhibiting and studying these systems as well as analyzing existing works, where the design practice informed our theoretical thinking while our theoretical thinking informed further design iterations in return. For example, exhibiting TastyBeats reminded us of the value of "spilling" as part of playful engagement [39], which informed strategy 2, in turn leading to a redesign of an earlier version of Arm-A-Dine's gripper. As such, our approach was an iterative process in which thinking about eating and play had influenced our design practice and vice versa, similar to the process used in prior work that also engaged a set of exemplary systems to derive an initial understanding of an emerging field [8,52,54]. We, therefore, believe our approach is also useful here. We acknowledge that this approach is a "messy" one, where theorizing is interspersed with "tinkering" [32] activity and thus reflects the reality of a design research lab. We have involved at least one designer of each of our systems into the process of deriving the strategies. We used whiteboards, affinity diagrams and "thinking through writing" while also looking back at the original papers to identify the strategies. This also involved eating, playing and going to restaurants that feature some of the commercial examples. We acknowledge that this process did not, and was not intended to, result in an exhaustive list of strategies. The strategies should rather be seen as inspiration and mark the beginning of an initial structured understanding. Future systems can be derived from these strategies; however, it is not expected for all strategies to be incorporated. Overall, we believe that the practicality of our work facilitates a valuable initial understanding of how to design interactive technology to facilitate experiencing eating as play.

4.1 Strategy 1: Make Eating Challenging

This strategy is concerned with the extent to which the system makes eating challenging as a way to support experiencing eating as play. This contrasts the common perception that eating is increasingly "easier", especially with fast food that is not only easy to afford but also easy to consume. Making eating challenging, we believe, resonates with Suit's work around play and games that highlights the benefit of "unnecessary challenges" [74]. We propose that making eating "unnecessarily" challenging could be a useful strategy for experiencing eating as play. Past non-digital work has already designed hard-to-use cutlery to facilitate more playful eating experiences [76]. Here, we highlight that interactive technology affords novel opportunities to make eating challenging, going beyond what we already know about from traditional game design in regards to creating challenges for players (where challenge is mostly of a virtual nature): when it comes to food, we point out that designers can create additional challenges, for example, by engaging with the fact that during prolonged play, players will become hungry and want to eat, so limiting access to food through a digitally controlled lock is an extreme example of how digital technology can make eating challenging. Exemplifying our systems, we have identified the following implementation options. Designers can make eating challenging by:

- limiting the bodily ability to feed
- requiring additional effort for food selection
- removing the ability to sense food (for example by removing vision)
- delaying the time to eat

For example, in Arm-A-Dine, eating and feeding is made challenging through the use of a robotic third arm. The bodily action of feeding oneself and others by moving food from the plate to the mouth is hindered by the limited dexterity of the robotic arm. The robotic arm also needed to be supported by moving one's body to pick up the food and feeding it to others. As such, the system **limited the bodily ability to feed** oneself and others. **Additional effort for food selection was required** as the facial expressions of participants affected the robotic third arm's movement. Participants had to anticipate what their partners might want to eat next and how they felt. Participants welcomed these challenges as the associated joyful expressions suggested: "*I really like the fact that my arm is controlled by her and her arm is controlled by me although I cannot control my facial expression*". The increased challenge appeared to make eating "strange", reminding us of Dewey's work about the benefits of making things "strange again" as a strategy to engage people with emotional experiences [41]; this seemed to contribute to the playful character of the experience.

YBEtS! makes eating challenging by **removing vision of the food** via a VR headset **limiting the bodily ability** to feed. This is further exacerbated by the rule that the other player feeds the VR player by wrapping his/her arms around him/her. Participants reported that this unnecessary challenge facilitated a playful engagement that appeared to contribute to the social bonding character of the experience: "*So there was a lot of partner work involved, which was good because that sort of creates a bonding effect, which is really cool. I found it helped me to get to know the stranger much quicker. Even though you are not talking about personal things, you feel like you're bonding because you are helping each other in a situation where you have to communicate and help one another or the other person to survive.*"

In EdiPulse, the process of getting to the chocolate was made challenging by **delaying the time to eat**. The chocolate needed to be tempered first, then filled into the 3D-food printer, and then the printing process of the representations was time consuming. We note that most 3D printing research aims to reduce 3D printing time (e.g. [55]). However, participants appreciated the rather slow time of chocolate printing. Firstly, they appreciated the smell emitted from the slow process of tempering the chocolate, facilitating pleasant sensations (which can be a key element of playful experiences [42]). As such, playful eating, in contrast to traditional video games, can engage with the notion of eating anticipation through pleasant (smell) sensations. Secondly, watching their data being printed was akin to a food "reveal" (similar to a waiter revealing the food when lifting a Cloche dome plate cover) that was associated with a sense of discovery (with discovery being another key element of playful experiences [42]). One participant commented: "*Because of the nature of the machine, you keep watching it doing the print. It is a much nicer process to see how it reveals my data as opposed to directly knowing what it is going to say.*"

Similarly, TastyBeats also **delayed the time to eat**. Participants were entertained by the mixing process, which took time. The benefit was that participants learned about the ingredients of their drink, however it also delayed replenishment of lost bodily fluids, which is particularly pertinent after an exhaustive workout.

Both LOLLio and Chewing Jockey make eating more challenging through the technology hardware that the user is required to wear and hold. In LOLLio, users had to carry a laptop and the accelerometer-containing device while in Chewing Jockey, users had to wear a photo-reflector on their face. As such, eating was made more challenging by **limiting the bodily ability to feed** oneself as a result of the technology inclusion, for example, users might want to chew more carefully so that the photo-reflector's tape does not fall off the skin. Here, the challenge arose as a byproduct of this technology inclusion, however we point out that designers working with food might want to consider such a challenge when aiming to integrate technology: would any technology inclusion make eating more challenging, and if so, could this be used to support experiencing eating as play?

4.2 Strategy 2: Break Cultural Norms Around Eating

This strategy is concerned with the extent to which the system supports breaking cultural norms around eating as a way to support experiencing eating as play. Breaking cultural norms can be a powerful strategy to facilitate intriguing playful experiences, as pointed out by work on sensor-based play [54] that highlights the benefits of making participants "uncomfortable" [7]. Similarly, Lucero et al. [42] described the potential of "breaking social rules and norms" when it comes to supporting playful experiences; here, we extend this by describing how technology design can be used to break cultural norms around eating. We identified the following implementation options; designers can challenge cultural norms by:

- promoting the breaking of eating etiquette
- facilitating feeding others
- promoting the spilling of food
- facilitating feeding non-favorite foods

Arm-A-Dine challenges the (at least Western) cultural norm of using cutlery to pick up food, **promoting the breaking of eating etiquette**. The robotic third arm has a gripper installed at the end that picks up the food and then feeds it to the wearer's or partner's mouth (the gripper was cleaned before each use). The gripper could have also held cutlery, however preliminary experimentation of using a spoon with the robotic arm showed that this would make picking up food very difficult. In response, the gripper itself picked up the food. As the robotic arm was attached to the human body and looked a little like a hand, it appeared that participants not only engaged playfully in the challenge of picking up the food using this robotic third arm but it also facilitated social interactions around eating with cutlery versus with hands. Participants reminisced about their holidays in other cultures where they eat with their hands and how this experience reminded them of this. For example: *"It is not common in our culture to eat with hands, but this experience reminded me of travels to Sri Lanka where I saw*

people eating food with their hands, and it was very interesting to see people eating this way". The study highlighted how eating with hands, especially if the "hand" is of a robotic arm, can be playful and facilitate a "less formal" atmosphere. This can spark laughter and conversations about what makes a "hand" a hand that is okay getting food in contact with, and what new etiquettes should exist if a piece of food is dropped onto the table: is it ok to pick it up with the robotic third arm and feed it to the other person?

In YBEtS!, participants showed similar signs of engagement where they ate with hands. The second player put food into the VR player's mouth, which was a rather personal action. This **facilitation of feeding others** resulted in much laughter, with plenty of **food being spilled**. The playful engagement with rather intimate actions around eating contributed to the bonding between participants (similar to how prior work suggested bodily play can facilitate social bonds [52]). Participants reflected on the importance of trust. They described how easy it was to cause someone discomfort or feed something they do not like. Players were intrigued by this opportunity of intentionally or unintentionally breaking the cultural norm of **feeding non-favorite foods** to the VR player. Participants also requested hot chilies to secretly feed their partner during the study. YBEtS! presented a certain risk in feeding food not preferred by the VR player compared to digital games. In digital games, if the avatar ate a virtual toxic item, it might result in loss of health or a "Game Over" and the player can easily retry. However, bad indigestion can be the result of certain real food and may require medical treatment well beyond the game's end. As such, challenging cultural norms around feeding anything else than desirable food can be intriguing, however game designers need to consider the risks involved.

In EdiPulse, the cultural norm around sharing sweets such as chocolate was broken as the data embedded into the chocolate was more personal. Participants, who had invested physical effort into the printing of the food, felt that they were hesitant to share their chocolate pieces containing their bodily data. As one participant explained: "*Food is generally shared, but once it has data elements to it, it becomes more personal.*" Participants had invested physical effort into the production of the food, which changed how they engaged with the cultural norm of sharing their sweets. Participants wanted to "return" this bodily effort "back" into their bodies and not "waste" it on someone else. One participant said: *"It was a personal reward for what I have done. I would not give it to others since I did all the hard work. I know, it sounds really bad but I kept these treats to myself."* This decreased willingness to share their food was an interesting side-effect of the associated study. Although participants joked within their families about not sharing their chocolate and how it facilitates a friendly rivalry, it may not have contributed positively to the playful experience overall. Despite this, participants were free to share their chocolate prints and even demonstrate to other participants how their printouts represented their bodily data. We note that with the rapid increase of digital sensors in society, there will be more and more opportunities to combine data with food and hence make it more personal. This might result in a reduced inclination to share food, which might be detrimental to the desired user experience, thus designers should carefully consider any system component that breaks this cultural norm.

TastyBeats breaks the cultural norm of not wasting food. Here it is the **spilling of food** (i.e. drinks) that leads to waste [39]: the fountain mechanism meant that the liquid might miss their containers causing splatters. This spilling facilitated great joy in participants and contributed to the playful character of the experience, reminiscent of when children enjoy making a mess when eating or the joy arising from "food fights". Most participants put the system into their kitchen, which meant they could easily clean up any spilling, but it also appeared that the social character of the kitchen, where food spilling is common and highly visible to others, underlined the positive side of spilling.

LOLLio breaks the cultural norm of feeding only food the other person likes: one of the games for the system involves the computer feeding a group of participants (each with their own lollipop) a sour taste, and then co-players have to guess who received the sour taste while hiding their own affective (negative) response to not reveal if they received the sour taste themselves. As such, LOLLio **facilitates feeding undesirable foods**, but rather than using it as a (game-)punishment, it uses food's strong affinity with affective responses (such as scrunching one's face when eating something unpleasant) to enable a guessing game.

Chewing Jockey **breaks the eating etiquette** of eating something that is "alive" (here: anthropomorphized food), in particular where they scream in pain: the chewing of the food results in screams as if the food items are characters that have emotions. As such, players are engaging with the cultural norm that eating food is ok, but eating creatures is not. Here, the player has "superpowers" [2] as he/she can, by eating, cause pain to

small characters. Chewing Jockey engages with this make-believe (a play element computer games are particularly strongly affiliated with [71]) through sound, drawing on prior work that highlights the potential of make-believe through giving participants "superpowers" in order to facilitate playful experiences [1]. With Chewing Jockey participants can experience what it would sound like if we would eat little creatures, without causing any pain to those creatures. This draws on prior work that pointed out that being able to try out options without any real-world consequences can be a powerful resource for playful experiences [71], here we point to the fact that eating "destroys" food through chewing, a notion that technology is able to reframe as done here in the form of "eating characters" through sound facilitation.

4.3 Strategy 3: Design Across the Various Stages of the Eating Experience

This strategy is concerned with the extent to which the system engages with the various stages of the eating experience. Looking at a more holistic view of eating beyond the immediate eating action relates to the expansion of the "magic circle", which highlights to look beyond the immediate play action in order to result at pervasive play [50]. To guide such more holistic approaches to interactive experiences, Benford et al. have proposed to look also at the individual stages before and after the "core" interaction stages designers are usually concerned with [6]. We subscribe to this and examine this in regard to eating, detailing five different stages: feeding, digestion, chewing, preparation, and sourcing. When we refer to stages, we are not looking at the food chain (like Hee-Jeong Choi et al. [16]) but rather at the stages unique to food consumption and propose that designers can benefit from considering designing across the various stages of the eating experience. In particular, they can:

- include the feeding stage
- include the digestion stage
- include the chewing stage
- include the preparation stage
- include the sourcing stage

Arm-A-Dine was mostly concerned with the **feeding stage**. However, a future iteration can **include the preparation stage** where participants prepare the food with three arms. The robotic third arm could also be involved (at least to some extent) in the **digestion stage** of the eating experience: in some cultures, rubbing one's belly is a sign of being full and having enjoyed the food; here, the robotic third arm could do the rubbing action, and it would be interesting to see whether the cultural meaning will be perceived in the same way.

YBEtS! only engages with the **feeding stage.** However, we can envision that the VR headset could also play a role in the **preparation stage**. The game could ask the VR player (who cannot see the food) to prepare the food based on the instructions from the non-VR player, for example. Again, this could result in a very messy yet playful experience.

EdiPulse engaged with the **preparation stage**, particularly how the 3D-printer prepared the chocolate. Participants were supplied with the most suitable chocolate for the 3D-printer (dark chocolate). However, we can envision future iterations where the system reminds users at the supermarket to not forget to buy dark chocolate for the 3D-printer. This way, the system would support participants being able to select what type of dark chocolate they prefer. This could facilitate an even more delightful experience resulting from the fact that the system also considered the **sourcing stage** of the eating experience.

TastyBeats engages with the **preparation stage**, as the mixing was made a deliberate part of the drinking process (in contrast, the mixing could have also occurred "behind the scenes", without the involvement of any jets of liquid in the air). Participants also engaged with the sourcing stage by considering what other liquids they could feed into the system; however, this was not digitally augmented (yet).

Chewing Jockey does not engage much with the different stages except the **chewing stage**. However, we can envision a future version in which the digestion of the food is augmented with funny sounds, drawing for example on the silliness of "farting" noises, similar to the previously proposed food sounds work [78,95]. As such, the work would be extended to also engage with the **digestion stage**.

LOLLio uses an accelerometer to sense how people hold the lollipop. We can, therefore, say the system engages with the **chewing stage** (here: sucking), at least to some extent. This is particularly important with lollipops, as changing the position in the mouth is usually associated with an enriched eating experience; as such, we suggest that using the position of food in the mouth as a digital input can be another resource designers could consider in their work.

4.4 Strategy 4: Reduce Autonomy Over the Eating Process

This strategy is concerned with the extent to which the system reduces participants' autonomy over the eating

process. Autonomy refers to having interesting and meaningful choices and opportunities that allow people to act volitionally, while having a high degree of autonomy is usually considered desirable in digital games [29]. We argue that when it comes to eating, reducing autonomy could be worthwhile for designers to think about when aiming to support experiencing eating as play. This might even directly address some of today's eating issues such as overconsumption, however we leave providing evidence for future work. We identified that designers could reduce autonomy over the eating process by:

- limiting the food selection opportunities
- limiting the food quantity

Arm-A-Dine participants experienced reduced autonomy as they were not able to select their food (**limited food selection opportunities**) when the other player presented it. This provided opportunities for players to learn how to settle with foods presented to them regardless if it was their favorite. This reduced autonomy resulted in much laughter, especially when a player selected his/her favorite food, but it was then presented to the other player. One participant said: "*I was paying attention to [our] facial expressions: depending on what my [partner] picks, I used to change my expressions and try to feed him the food that he doesn't like [laughs]*".

In YBEtS!, VR players experienced reduced autonomy over the eating process as they had **limited food selection opportunities** because they could not see the food. This reduced autonomy resulted in a reliance on the other player, contributing to playfulness. For example, one participant commented: *"I didn't mind that I was not able to see what was happening in the game, I was more worried about my partner running into things or even dying in the game if I don't get the food to him fast enough; to be fast enough to be able to continue, I think that was more where my mind was, than like: 'Oh no, I can't see anything.' I wanted to be the best help I could in completing the game".*

In EdiPulse, participants experienced reduced autonomy over the eating process in terms of not being able to eat as much chocolate as they wanted (**limiting the food quantity**). Although the chocolate was always present in their kitchen, the system afforded eating only in controlled amounts. One participant commented: *"Although chocolate was so accessible, you also knew that every night you would have a bite of chocolate. And when I did not exercise, I knew from the system that my body did not ask me to eat more chocolate. So, it really made me eat less chocolate than what I normally do".*

Similarly, TastyBeats participants experienced reduced autonomy as the system **limited how much to drink**. The participants could have mixed the drinks themselves, allowing them the opportunity to determine the content and amount. However, the reduced autonomy led to participants watching the mixing action unfold, often with their family members. This facilitated a sense of anticipation as participants were eager to see the representation of their data. The system served the role of a bartender mixing participants' drinks based on their data.

Chewing Jockey **limits the food selection opportunities** as the system works best with chewing gummy sweets that look like little creatures, both technically and experientially.

LOLLio also facilitates experiencing reduced autonomy as diners have **limited food selection opportunities**: the system delivers either a sour or a sweet taste, which sit on the opposite ends of the taste spectrum. Furthermore, although participants can control whether they put the lollipop into their mouth or not, they cannot control the injection of the citric acid into their mouth. This reduced control over what food (here: taste) will be selected for them appears to facilitate a sense of suspense that contributes to the playful character of the experience.

4.5 Strategy 5: Playfully Extend the Social Aspect of Eating

This strategy is concerned with the extent to which the system playfully extends the social aspect of eating. Although one can eat alone, eating is very much a social endeavor, highlighted by the term commensality, the "practice of sharing food and eating together in a social group such as a family" [61]. We see an opportunity to extend the social aspect of eating and hence, the playful character of eating as a group, but also highlight the fact that many video games are single-player. Even when playing with others, digital content can "draw" players in to the extent that they end up playing "alone together" [21]; hence we believe that designers need to be aware of this when creating digital play around eating. Prior work has highlighted the opportunity to enable people to eat over a distance [5], here we note that technology offers additional opportunities to extend the social aspect of eating by:

- involving others through turning eating into a spectacle
- involving others through the multi-sensory appeal of food

Arm-A-Dine participants reported that the robotic third arm **involved others through turning eating into a spectacle**. Bystanders were intrigued how the system functioned and participants involved them by presenting food to them using their robotic third arm. Future studies can explore if such spectacles can involve bystanders in the long run beyond the novelty effect.

Similarly, YBEtS! **involved others through turning eating into a spectacle**. Bystanders wanted to play next after observing the physical world action that was regarded as an intriguing spectacle (they were also able to see the virtual world on a large monitor). As such, the spatial setup design facilitated the emergence of a spectacle that enticed to get involved (even though not in the immediate eating process, but in the next round).

In EdiPulse, the 3D-printing process appeared to **involve others through the multi-sensory appeal of food**. First, the smell produced by tempering chocolate was smelt by all members at home in every room. They appreciated the smell very much thus gathering around the system to see someone "producing data to be eaten". Secondly, the noise of the 3D-printer informed them that chocolate would soon be ready to be consumed. Participants appreciated this multi-sensory social aspect, comparing it to cooking, where the smell and noise of the activity can attract others.

TastyBeats **facilitates involving others through turning eating (drinking) into a spectacle**. The mixing of the drinks was inspired by the performative actions of bartenders, which seems to be an appeal to the person drinking as much as any bystander. Here we extend this by proposing that interactive technology design can learn from such performative actions around food (and drinks) that turns eating into a spectacle.

Chewing Jockey uses audio as a powerful medium for a playful eating experience. The audio is delivered through headphones; however, we can envision future versions where the sound is shared across the dining table through speakers to **facilitate involving others through the multi-sensory appeal of food**.

The designers of LOLLio propose the delivery of a sour or sweet taste as part of a video game, which could be extended to networked play, for example by including a videoconference that shows participants' facial responses to high concentrations of the sour liquid. This could **facilitate involving others through turning eating into a spectacle** that is distributed across a network to reach a large audience.

5 Discussion

We acknowledge that playing with food can also result in adverse outcomes, such as food waste, a perceived decreased value of food or the raising of cultural insensitivities. Nevertheless, we highlight the widely lamented global issues society faces as a result of a misaligned relationship with food, ranging from obesity to eating disorders [83]. We argue that now is the time to re-examine our engagement with food from every angle. Prior HFI work has made similar arguments, and theoretical work on examining these different angles is currently being conducted (e.g. [9,10,20]). We draw on prior overview work on HFI [11] and extend it through a particular lens for playful design. Furthermore, we draw on other design works that have also examined the coming together of play and eating (e.g.[3,22,23,35,46, 48,63,64,68,77,79]), however, these works present individual systems that focus on one particular aspect of human-food interaction or a specific technical detail. As such, there is still a shortage of design knowledge derived from looking back and reflecting on the designs beyond specific instances. We believe we can advance the field by examining our craft knowledge of having designed several playful eating systems. Together with looking at other's design work, we hope to be able to paint a more complete picture of how design can facilitate experiencing eating as play.

Furthermore, we acknowledge that experiencing eating as play is not an experience where participants either experience eating as play or not, but rather an emerging phenomenon on a scale in-between no play and too much play (for example when the food is only being played with, but not eaten). Moreover, we also acknowledge that our approach comes with all the limitations typical for design research [27], for example, our work only touches upon cultural aspects as long-term placements are still missing (although all our systems have been accompanied with qualitative studies). Also, as we are only focusing on a small set of examples, rather than all playful eating systems, we balance coverage with a more detailed look that allows for more practical design insights thanks to our craft that allows drawing on its associated tacit design knowledge. Of course considering additional examples would allow for a more advanced understanding while also possibly allowing for more opportunities to test the proposed strategies across a range of designs. We also acknowledge that we are aware that our work can be criticized to trivialise food by focusing on the eating actions, where food is digested as a playful activity, but the type of food can be rather indepent from the

interactive system. This is in particular evident by the fact that the type of food is mostly not (yet) sensed. Investigations into this will be of benefit for the future of the field, we hope. Nevertheless, we believe that with our work from a perspective of interaction design practice, we can contribute to a more structured design understanding of the coming together of eating and play in order to support people in experiencing eating as play.

6 Conclusions

There is a growing interest in the intersection between interactive technology and eating. We believe that this trend can serve not only instrumental but also experiential purposes. In particular, we argue that engaging with interactive technology to facilitate experiencing eating as play is an important area of research. However, so far, there is only limited design knowledge available on how to make this a reality. To illustrate our thinking around this topic, we have articulated a set of design strategies based on our experiences of having designed, exhibited and studied a series of playful eating systems and related work. We hope our work can encourage game designers to consider how their expertise could be useful for the future of eating. Furthermore, food experts and chefs may be inspired by our work to consider the skills of game designers when creating playful eating experiences. Overall, we hope that this will result in more opportunities to experience eating as play. Ultimately, with our work, we aim to facilitate a future where eating is more playful.

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REFERENCES

[1] Josh Andres, Julian de Hoog, Jürg von Känel, Julian Berk, Bach Le, Xizi Wang, Marcus Brazil, and Florian Mueller. 2016. Exploring Human – eBike Interaction to Support Rider Autonomy. *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play. Companion Extended Abstracts - CHI PLAY Companion '16*: 85–92. https://doi.org/10.1145/2968120.2987719

[2] Josh Andres, Julian de Hoog and Florian Mueller. 2018. "I Had Super-Powers When Ebike Riding" Towards Understanding the Design of Integrated Exertion. In *Proceedings of 2018 Annual Symposium on Computer-Human Interaction in Play*. ACM, 3242688, 19-31. http://dx.doi.org/10.1145/3242671.3242688

[3] Takahiro Arakawa and Masa Inakage. 2007. Mamagoto: "Playing" with Food. In *Proceedings of ACM SIGGRAPH 2007 posters*. ACM, 1280895, 161. http://dx.doi.org/10.1145/1280720.1280895

[4] Peter Arnold. 2017. You Better Eat to Survive! Exploring Edible Interactions in a Virtual Reality Game. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17), 206–209. https://doi.org/10.1145/3027063.3048408

[5] Pollie Barden, Rob Comber, David Green, Daniel Jackson, Cassim Ladha, Tom Bartindale, Nick Bryan-Kinns, Tony Stockman, and Patrick Olivier. 2012. Telematic dinner party. In *Proceedings of the Designing Interactive Systems Conference on - DIS '12*, 38. https://doi.org/10.1145/2317956.2317964

[6] Steve Benford, Gabriella Giannachi, Boriana Koleva and Tom Rodden. 2009. From Interaction to Trajectories: Designing Coherent Journeys through User Experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1518812, 709-718. http://dx.doi.org/10.1145/1518701.1518812

[7] Steve Benford, Chris Greenhalgh, Gabriella Giannachi, Brendan Walker, Joe Marshall, and Tom Rodden. 2012. Uncomfortable interactions. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*, 2005. https://doi.org/10.1145/2207676.2208347

[8] Steve Benford, Holger Schnadelbach, Boriana Koleva, Rob Anastasi, Chris Greenhalgh, Tom Rodden, Jonathan Green, Ahmed Ghali, Tony Pridmore, Bill Gaver, Andy Boucher, Brendan Walker, Sarah Pennington, Albrecht Schmidt, Hans Gellersen, and Anthony Steed. 2005. Expected, sensed, and desired: A framework for designing sensing-based interaction. *ACM Transactions on Computer-Human Interaction (TOCHI)* 12, 1: 3–30. https://doi.org/10.1145/1057237.1057239

[9] Ferran Altarriba Bertran and Danielle Wilde. 2018. Playing with Food: Reconfiguring the Gastronomic Experience through Play. In *Proceedings of Conference on Food Design and Food Studies (EFOOD 2017), October*.

[10] Ferran Altarriba Bertran, Samvid Jhaveri, Rosa Lutz, Katherine Isbister and Danielle Wilde. 2018. Visualising the Landscape of Human-Food Interaction Research. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems*. ACM, 3205443, 243-248. http://dx.doi.org/10.1145/3197391.3205443

[11] Ferran Altarriba Bertran, Samvid Jhaveri, Rosa Lutz, Katherine Isbister and Danielle Wilde. 2019. Making Sense of Human-Food Interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, 678.

[12] Ferran Altarriba Bertran, Elena Marquez Segura, Jared Duval and Katherine Isbister. 2019. Chasing Play Potentials: Towards an Increasingly Situated and Emergent Approach to Everyday Play Design. In *Proceedings of the Designing Interactive Systems Conference*. ACM, 1265-1277. http://dx.doi.org/10.1145/3322276.3322325

[13] J A Brillat-Savarin. 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*.

[14] Lilian Cheung and Thich Nhat Hanh. 2010. *Savor: Mindful eating, mindful life*. HarperOne.

[15] Yoram Chisik, Patricia Pons and Javier Jaen. 2018. Gastronomy Meets Ludology: Towards a Definition of What It Means to Play with Your (Digital) Food. In *Proceedings of 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*. ACM, 155-168.

[16] Jaz Hee-jeong Choi, Marcus Foth, and Greg Hearn. 2014. *Eat, cook, grow: Mixing human-computer interactions with human-food interactions*. MIT Press.

[17] Rob Comber, Jettie Hoonhout, Aart Van Halteren, Paula Moynihan, and Patrick Olivier. 2013. Food practices as situated action: exploring and designing for everyday food practices with households. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2457–2466.

[18] Hilary Davis, Frank Vetere, Martin Gibbs, and Peter Francis. 2012. Come play with me: designing technologies for intergenerational play. *Universal Access in the Information Society* 11, 1: 17–29.

[19] Yash Dhanpal Mehta, Rohit Ashok Khot, Rakesh Patibanda and Florian Mueller. 2018. Arm-a-Dine: Towards Understanding the Design of Playful Embodied Eating Experiences. In *Proceedings of 2018 Annual Symposium on Computer-Human Interaction in Play*. ACM, 3242710, 299-313. http://dx.doi.org/10.1145/3242671.3242710

[20] Marketa Dolejsova. 2018. Edible Speculations in the Parlour of Food Futures. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 3188406, 1-10. http://dx.doi.org/10.1145/3170427.3188406

[21] Nicolas Ducheneaut, Nicholas Yee, Eric Nickell and Robert J Moore. 2006. Alone Together?: Exploring the Social Dynamics of Massively Multiplayer Online Games. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*. ACM, 407-416.

[22] Florian Echtler and Raphael Wimmer. 2014. The Interactive Dining Table, or Pass the Weather Widget, Please. In *Proceedings of the Ninth ACM International Conference on Interactive Tabletops and Surfaces*. ACM, 2669525, 419-422. http://dx.doi.org/10.1145/2669485.2669525

[23] Nur Ellyza Abd Rahman, Azhri Azhar, Mohammad Abdullah Mohamad Johar, Kasun Karunanayaka, Adrian David Cheok, Jade Gross and Andoni Luis. 2016. Magnetic Dining Table and Magnetic Foods. In *Proceedings of the 13th International Conference on Advances in Computer Entertainment Technology*. ACM, 3001809, 1-6. http://dx.doi.org/10.1145/3001773.3001809

[24] Etxanobe. 2018. El Restaurante Etxanobe es ahora El Atelier, con su anexo La Despensa. Retrieved April 12, 2018 from https://etxanobe.com/

[25] Hasan Shahid Ferdous, Frank Vetere, Hilary Davis, Bernd Ploderer, Kenton O'Hara, Rob Comber, and Geremy Farr-Wharton. 2017. Celebratory Technology to Orchestrate the Sharing of Devices and Stories during Family Mealtimes. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*: 6960–6972. https://doi.org/10.1145/3025453.3025492

[26] Kentaro Fukuchi, Kazuhiro Jo, Akifumi Tomiyama, and Shunsuke Takao. 2012. Laser Cooking: a Novel Culinary Technique for Dry Heating using a Laser Cutter and Vision Technology. *Proceedings of the ACM multimedia 2012 workshop on Multimedia for cooking and eating activities - CEA '12*: 55–58. https://doi.org/10.1145/2390776.2390788

[27] Bill Gaver and John Bowers. Annotated Portfolios. *interactions* 19, 4 (2012), 40-49.

[28] Tom Gayler, Corina Sas and Vaiva Kalnikaite. 2019. Taste Your Emotions: An Exploration of the Relationship between Taste and Emotional Experience for Hci. In *Proceedings of the 2019 on Designing Interactive Systems Conference*. ACM, 1279-1291.

[29] JP Gee, Scott Rigby, and Richard M Ryan. 2012. Glued to Games: How Video Games Draw Us In and Hold Us Spellbound. *American Journal of Play*: 510–511. https://doi.org/10.1007/s13398-014-0173-7.2

[30] Andrea Grimes and Richard Harper. 2008. Celebratory Technology : New Directions for Food Research in HCI. *CHI 2008*: 467–476. https://doi.org/10.1145/1357054.1357130

[31] Niels Henze, Thomas Olsson, Stefan Schneegass, Alireza Sahami Shirazi and Kaisa Väänänen-Vainio-Mattila. 2015. Augmenting Food with Information. In *Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia*. ACM, 258-266.

[32] Lars Erik Holmquist. *Grounded Innovation: Strategies for Creating Digital Products*. Elsevier, 2012.

[33] Kristina Höök and Jonas Löwgren. 2012. Strong concepts: Intermediate-Level Knowledge in Interaction Design Research. *ACM Transactions on Computer-Human Interaction* 19, 3: 1–18. https://doi.org/10.1145/2362364.2362371

[34] Studio ID. 2018. Inamo Restaurant London. Retrieved April 12, 2018 from http://www.inamo-restaurant.com/

[35] Azusa Kadomura, Cheng-Yuan Li, Koji Tsukada, Hao-Hua Chu and Itiro Siio. 2014. Persuasive Technology to Improve Eating Behavior Using a Sensor-Embedded Fork. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. ACM, 2632093, 319-329. http://dx.doi.org/10.1145/2632048.2632093

[36] Rohit Ashok Khot, Deepti Aggarwal, Ryan Pennings, Larissa Hjorth, and Florian Floyd Mueller. 2017. EdiPulse: Investigating a Playful Approach to Self-monitoring through 3D Printed Chocolate Treats. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*: 6593–6607. https://doi.org/10.1145/3025453.3025980

[37] Rohit Ashok Khot, Jaz Hee-Jeong Choi, 2017. FoodCHI. http://datamaterialities.org/foodchi.html

[38] Rohit Ashok Khot, Jeewon Lee, Deepti Aggarwal, Larissa Hjorth, and Florian "Floyd" Mueller. 2015. TastyBeats: Designing Palatable Representations of Physical Activity. *Proceedings of the ACM CHI'15 Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/2702123.2702197

[39] Rohit Ashok Khot, Jeewon Lee, Larissa Hjorth and Florian Mueller. 2015. Tastybeats: Celebrating Heart Rate Data with a Drinkable Spectacle. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, 2680545, 229-232.

[40] Naoya Koizumi, Hidekazu Tanaka, Yuji Uema, and Masahiko Inami. 2011. Chewing jockey. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE '11*, 1. https://doi.org/10.1145/2071423.2071449

[41] Tuck Leong, Steve Howard and Frank Vetere. 2008. Choice: Abidcating or Exercising? In *Proceeding of the conference on Human factors in computing systems*. ACM. http://dx.doi.org/http://doi.acm.org/10.1145/1357054.1357168

[42] Andres Lucero and Juha Arrasvuori. 2010. Plex Cards: A Source of Inspiration When Designing for Playfulness. In Proceedings of the 3rd International Conference on Fun and Games. ACM, 28-37.

[43] Deborah Lupton. 1998. Food, the Body and the Self. *London: SAGE Publications Ltd.*

[44] Mail Online. 2018. Seafood served with an ipod: Heston Blumenthal's latest recipe. Retrieved April 12, 2018 from http://www.dailymail.co.uk/news/article-448840/Seafood-served-ipod-Heston-Blumenthals-latest-recipe.html

[45] Lena Mamykina, Elizabeth Mynatt, Patricia Davidson, and Daniel Greenblatt. 2008. MAHI: investigation of social scaffolding for reflective thinking in diabetes management. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 477–486.

[46] Anna Mansour, Mugdha Barve, Sushama Bhat and Ellen Yi-Luen Do. 2009. Munchcrunch: A Game to Learn Healthy-Eating Heuristics. In *Proceedings of the 8th International Conference on Interaction Design and Children*. ACM, 1551818, 166-169. http://dx.doi.org/10.1145/1551788.1551818

[47] Dan Maynes-Aminzade. 2005. Edible Bits: Seamless Interfaces between People, Data and Food. *Chi 2005*: 2207–2210.

[48] Robb Mitchell, Alexandra Papadimitriou, Youran You and Laurens Boer. 2015. Really Eating Together: A Kinetic Table to Synchronise Social Dining Experiences. In *Proceedings of the 6th Augmented Human International Conference*. ACM, 2735822, 173-174. http://dx.doi.org/10.1145/2735711.2735822

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

[50] Markus Montola, Jaakko Stenros and Annika Waern. Pervasive Games: Theory and Design. Morgan Kaufmann (Burlington, MA, USA), 2009.

[51] Christiane Moser and Manfred Tscheligi. 2013. Playful Taste Interaction. In *Proceedings of the 12th International Conference on Interaction Design and Children*. ACM, 2485828, 340-343. http://dx.doi.org/10.1145/2485760.2485828

[52] Florian Mueller, Darren Edge, Frank Vetere, Martin R Gibbs, Stefan Agamanolis, Bert Bongers, and Jennifer G Sheridan. 2011. Designing sports: a framework for exertion games. *Proceedings of*

the 2011 annual conference on Human factors in computing systems - CHI '11: 2651–2660. https://doi.org/10.1145/1978942.1979330

[53] Florian Mueller, Tuomas Kari, Rohit Khot, Zhuying Li, Yan Wang, Yash Mehta and Peter Arnold. 2018. Towards Experiencing Eating as a Form of Play. In *Proceedings of 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*. ACM, 3271528, 559-567. http://dx.doi.org/10.1145/3270316.3271528

[54] Florian Mueller, Sophie Stellmach, Saul Greenberg, Andreas Dippon, Susanne Boll, Jayden Garner, Rohit Khot, Amani Naseem, and David Altimira. 2014. Proxemics play. *Proceedings of the 2014 conference on Designing interactive systems*: 533–542. https://doi.org/10.1145/2598510.2598532

[55] Stefanie Mueller, Tobias Mohr, Kerstin Guenther, Johannes Frohnhofen, and Patrick Baudisch. 2014. faBrickation : Fast 3D Printing of Functional Objects by Integrating Construction Kit Building Blocks. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*: 3827–3834. https://doi.org/10.1145/2556288.2557005

[56] M. Murer, I. Aslan, and M. Tscheligi. 2013. LOLLio - Exploring taste as playful modality. In *TEI 2013 - Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction*, 299–302. https://doi.org/10.1145/2460625.2460675

[57] Inc MyFitnessPal. 2018. MyfitnessPal. Retrieved from https://www.myfitnesspal.com/

[58] Takuji Narumi, Shinya Nishizaka, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. 2011. Meta cookie+: An illusion-based gustatory display. In *Lecture Notes in Computer Science*, 260–269. https://doi.org/10.1007/978-3-642-22021-0_29

[59] Jon Noronha, Eric Hysen, Haoqi Zhang, and Krzysztof Z Gajos. 2011. Platemate: crowdsourcing nutritional analysis from food photographs. In *Proceedings of the 24th annual ACM symposium on User interface software and technology*, 1–12.

[60] Project Nourished. 2017. Project Nourished - A Gastronomical Virtual Reality Experience. Retrieved from http://www.projectnourished.com/

[61] Elinor Ochs and Meray Shohet. 2006. The Cultural Structuring of Mealtime Socialization. *New Directions for Child and Adolescent Development*, 111: 35–49. https://doi.org/10.1002/cad

[62] Rita Orji, Julita Vassileva, and Regan L Mandryk. 2013. LunchTime: a slow-casual game for long-term dietary behavior change. *Personal and Ubiquitous Computing* 17, 6: 1211–1221.

[63] Joongsin Park, Bon-chang Koo, Jundong Cho and Byung-Chull Bae. 2015. Snackbreaker: A Game Promoting Healthy Choice of Snack Foods. In *Proceedings of 2015 Annual Symposium on Computer-Human Interaction in Play*. ACM, 2810331, 673-678. http://dx.doi.org/10.1145/2793107.2810331

[64] Nora Ptakauskaite, Priscilla Chueng-Nainby and Helen Pain. 2016. Supporting Social Innovation in Children: Developing a Game to Promote Health Eating. In *Proceedings of the 15th International Conference on Interaction Design and Children*. ACM, 2935980, 688-693. http://dx.doi.org/10.1145/2930674.2935980

[65] Nimesha Ranasinghe, Adrian David Cheok, and Ryohei Nakatsu. 2012. Taste/IP: the sensation of taste for digital communication. In *Proceedings of the 14th ACM international conference on Multimodal interaction*, 409–416.

[66] Nimesha Ranasinghe, Kuan Yi Lee, Gajan Suthokumar, and Ellen Yi Luen Do. 2016. Virtual ingredients for food and beverages to create immersive taste experiences: The sensation of taste as an electronic media. *Multimedia Tools and Applications* 75, 20: 12291–12309. https://doi.org/10.1007/s11042-015-3162-8

[67] Nimesha Ranasinghe, Gajan Suthokumar, Kuan-Yi Lee, and Ellen Yi-Luen Do. 2015. Digital Flavor: Towards Digitally Simulating Virtual Flavors. *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction*: 139–146. https://doi.org/10.1145/2818346.2820761

[68] Janet C. Read and Gavin Sim. 2014. Taking the Biscuit: Playful Interaction. In *Proceedings of 28th International BCS Human Computer Interaction Conference on HCI 2014 - Sand, Sea and Sky - Holiday HCI*. BCS, 2742997, 371-375. http://dx.doi.org/10.14236/ewic/hci2014.36

[69] Benjamin Ishak Resner. 2001. Rover@ Home: Computer mediated remote interaction between humans and dogs. Massachusetts Institute of Technology.

[70] Sag's mit Keksen. 2007. QKies - Sag's mit Keksen. http://qkies.de/. Retrieved April 12, 2018 from http://qkies.de/

[71] Katie Salen and Eric Zimmerman. 2004. Rules of Play: Game Design Fundamentals.

[72] Johannes Schöning, Yvonne Rogers, and Antonio Krüger. 2012. Digitally enhanced food. *IEEE Pervasive Computing* 11, 3: 4–6. https://doi.org/10.1109/MPRV.2012.40

[73] Charles Spence. 2017. *Gastrophysics: The New Science of Eating*. Penguin Publishing Group. Retrieved from https://books.google.com.au/books?id=585zDQAAQBAJ

[74] Bernard Suits. 2014. *The Grasshopper-: Games, Life and Utopia*. Broadview Press.

[75] The Fat Duck. 2018. The Fat Duck. Retrieved April 12, 2018 from http://www.thefatduck.co.uk/

[76] Emma Tucker. 2016. Designers craft purposefully absurd cutlery to slow down. Retrieved from https://www.dezeen.com/2016/08/14/absurd-jouw-cutl

[77] Chi Thanh Vi, Asier Marzo, Damien Ablart, Gianluca Memoli, Sriram Subramanian, Bruce Drinkwater and Marianna Obrist. 2017. Tastyfloats: A Contactless Food Delivery System. In *Proceedings of 2017 ACM International Conference on Interactive Surfaces and Spaces*. ACM, 3134123, 161-170. http://dx.doi.org/10.1145/3132272.3134123

[78] Yan Wang, Zhuying Li, Robert Jarvis, Rohit Ashok Khot and Florian Mueller. 2018. The Singing Carrot: Designing Playful Experiences with Food Sounds. In *Proceedings of 2018 Annual Symposium on Computer-Human Interaction in Play. Companion Extended Abstracts*. ACM, 3271512, 669-676. http://dx.doi.org/10.1145/3270316.3271512

[79] Yan Wang, Zhuying Li, Robert Jarvis, Rohit Khot and Florian Mueller. 2019. Iscream! In *CHI PLAY*. ACM, 1-4.

[80] Jun Wei and Adrian David Cheok. 2012. Foodie: Play with your food promote interaction and fun with edible interface. *IEEE Transactions on Consumer Electronics* 58, 2: 178–183. https://doi.org/10.1109/TCE.2012.6227410

[81] Jun Wei, Xuan Wang, RL Peiris, and Yongsoon Choi. 2011. CoDine: an interactive multi-sensory system for remote dining. *Ubicomp 2011: Ubiquitious Computing*: 21–30. https://doi.org/http://dx.doi.org/10.1145/2030112.2030116

[82] Danielle Wilde and Ferran Altarriba Bertran. Participatory Research through Gastronomy Design: A Designerly Move Towards More Playful Gastronomy. *International Journal of Food Design* 4, 1 (2019), 3-37.

[83] World Health Organization Who. 2010. Global recommendations on physical activity for health. *Geneva: World Health Organization*: 60. https://doi.org/10.1080/11026480410034349

[84] Rachel Zelkowitz. 2009. Play: How It Shapes the Brain, Opens the Imagination, and Invigorates the Soul. *Science News VO - 176*, 1: 31.

[85] Wen Wang, Lining Yao, Teng Zhang, Chin-Yi Cheng, Daniel Levine, and Hiroshi Ishii. 2017. Transformative Appetite: Shape-Changing Food Transforms from 2D to 3D by Water Interaction Through Cooking. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 6123–6132. https://doi.org/10.1145/3025453.3026019

[86] Florian Mueller, Richard Byrne, Josh Andres and Rakesh Patibanda. 2018. Experiencing the Body as Play. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 3173784, 1-13. http://dx.doi.org/10.1145/3173574.3173784

[87] Roger Caillois. *Man, Play, and Games*. University of Illinois Press, 1961.

[88] Rohit Ashok Khot, Deborah Lupton, Markéta Dolejšová and Florian Mueller. 2017. Future of Food in the Digital Realm. Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems. ACM, 1342-1345.

[89] Carlos Velasco, Felipe Reinoso Carvalho, Olivia Petit and Anton Nijholt. 2016. A Multisensory Approach for the Design of Food and Drink Enhancing Sonic Systems. Proceedings of the 1st Workshop on Multi-sensorial Approaches to Human-Food Interaction. ACM, 7.

[90] Natsuki Hamanishi, Michinari Kono, Shunichi Suwa, Takashi Miyaki and Jun Rekimoto. 2018. Flufy: Recyclable and Edible Rapid Prototyping Using Fluffed Sugar. In *Proceedings of the 23rd International Conference on Intelligent User Interfaces Companion*. ACM, 27.

[91] So Yeon Park, Sohyeong Kim and Larry Leifer. 2017. "Human Chef" to "Computer Chef": Culinary Interactions Framework for Understanding HCI in the Food Industry. In Springer International Publishing, 214-233.

[92] Ferran Altarriba Bertran, Danielle Wilde, Erno Berezvay and Katherine Isbister. 2019. Playful Human-Food Interaction Research: State of the Art and Future Directions. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. ACM, 3347155, 225-237. http://dx.doi.org/10.1145/3311350.3347155

[93] Rohit Khot, Florian Mueller, Human-Food Interaction. In Foundations and Trends in Human–Computer Interaction. 12, 4 (2019). 238-415.

[94] Peter Arnold, Rohit Ashok Khot and Florian Mueller. 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*. ACM, 398-408.

[95] Yan Wang, Zhuying Li, Robert S. Jarvis, Angelina Russo, Rohit Ashok Khot and Florian Mueller. 2019. Towards Understanding the Design of Playful Gustosonic Experiences with Ice Cream. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. ACM, 3347194, 239-251. http://dx.doi.org/10.1145/3311350.3347194