

Playful Human-Food Interaction Research: State of the Art and Future Directions

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ABSTRACT

In response to calls for sense-making in the field of Human-Food Interaction, we offer a systematic review of a subset of HFI works that we call *Playful HFI*—interventions that use game- or play-inspired mechanisms to add value to food-related experiences. To support our review, we offer a conceptual model of Playful HFI informed by: (i) the 34 publications in our dataset; (ii) theories of play, games and HFI; and (iii) previous reviews of play-related HCI. Our conceptual model and review characterise the current state of Playful HFI, highlight resemblances and differences with the broader field of HFI as a whole and surface challenges and opportunities in this new and exciting design space. Our contribution will help HFI scholars to explore new and increasingly playful avenues for the future of food technology and will empower the HFI community to better position (and critically reflect on) future research at the intersection of play, technology and food.

Author Keywords

Human-Food Interaction; HFI; Play; Playfulness; Games; Fun; Literature Review.

CCS Concepts

• **Human-centered computing** → HCI theory, concepts and models.

INTRODUCTION

Technology is increasingly present in people's lives, mediating everyday activities and tasks. Food practices are no exception. Technology is commonly used to: prepare food

(e.g. the *Thermomix* [65]); track consumption and waste habits (e.g. to promote food waste reduction [25]); enhance eating and drinking experiences in playful ways (e.g. by projecting visuals onto the dining table [4]); and more. How these technologies are designed and used impacts how people think about, engage with and experience both the food itself and the associated interactions. Research of this interplay between people, technology and food is called *Human-Food Interaction* (HFI) research. HFI is remarkably diverse and dynamic, and calls for sense-making around [14,15,19,23,44,52]. We recently conducted a Systematic Mapping Study (SMS) [2] of the HFI research landscape. The SMS visualised the dynamic nature of HFI and identified opportunities for research. It made visible a subset of HFI research projects that use game- or play-inspired mechanisms to explore how playfulness can add value to food-related experiences. We call this emerging research area *Playful HFI*. Playful HFI recognises play as an important aspect of human life and culture [11,37,63] and, as such, as an important vector to consider in HFI.

To understand the mechanisms of Playful HFI, and empower interested researchers to position their work in this exciting new field, we present a systematic review of 34 publications, analysed through criteria relevant to HFI, play and games research. Our findings afford critical reflection on the current state of Playful HFI, make visible trends and emerging challenges, and suggest new opportunities for research. Our study approach is novel, yet robust. The findings will empower designers and researchers to bring a more critical, reflective stance to Playful HFI technology development and strengthen research in this emerging area.

RELATED WORK

Human-Food Interaction research (HFI) embraces a broad spectrum of disciplines, methodologies and research agendas: cross-modal psychology (e.g. [64]), engineering (e.g. [40]), computer science (e.g. [57]), HCI (e.g. [53]), speculative design (e.g. [24]), and more [2]. Altarriba Bertran, Wilde, et al.'s Systematic Mapping Study of HFI maps out this landscape and provides a framework for monitoring and reflection [2]. They "provide conceptual and

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operational tools so that HFI researchers can engage with the literature and come to conclusions that reflect their own concerns", including: an online tool—the *HFI Lit Review App*—a comprehensive dataset of 270+ HFI-related publications, and a taxonomy for understanding them [2].

The subset of HFI that explores how food, games, play and playfulness can be brought together is what we are calling *Playful HFI*. A number of reviews have been conducted in this space. Chisik et al. review *gastroludology* (gastronomy and ludology) in eating and drinking [13], highlighting speculative approaches (e.g. [3,22]) as a promising way forward. Altarriba Bertran and Wilde review playfulness in *New Cookery* (high gastronomy) [3], demonstrating from the perspective of play theory that chef's approaches to play are limited and that diners would welcome an opening up of this space. Mueller et al. review three works from their lab to propose strategies that can assist researchers to facilitate playful eating experiences using novel technologies [55]. These reviews focus on eating or drinking. Yet, HFI also involves sourcing, storing and producing food, tracking food and food-related activities, speculating food futures, using food as a material practice to support thinking and learning, and more [2].

In their discussion of *celebratory technology*, Grimes and Harper propose alternative directions for HFI, emphasising the experiential dimension of food practices beyond eating [34]. They map out emerging design opportunities, but do not provide a comprehensive review. They also do not focus on play or playfulness per se. Rather, they explore the general potential of technology to augment food experiences.

Our review builds on Chisik et al., Mueller et al., Grimes and Harper, and Altarriba Bertran, Wilde, et al. to provide an in-depth analysis of Playful HFI. It moves beyond eating and drinking to include research into other food-related practices. The objective is to assist scholars to make sense of the landscape of Playful HFI research, find unexplored opportunities for impact, and think critically about future research in this space.

METHOD

Data Collection

To create our dataset, we began with Altarriba Bertran, Wilde et al.'s *HFI Lit Review App* [2]. We searched for the keywords: *game, games, play, playing, playful, playfulness, fun* and found 20 relevant publications. We then searched the *ACM database*, forming pairs of keywords combining *food* with our game- and play-related keywords and controlling for unrelated uses of play (such as to play a role), and found 11 additional papers. We searched *Google Scholar* and the archives of three game studies journals—*Game Studies* [30], *Games and Culture* [29], and *Journal of Games Criticism* [39]—using the same keyword combinations and filtering and found one additional paper. To complete our dataset, we

added a paper from our personal archives [32] and another recommended by our reviewers [45]. Those not included in [2] were added, to keep this community resource up to date.

The final dataset includes 34 publications: 2 journal articles, 9 full papers, 6 short papers, 1 spotlight paper, 1 case study paper, 2 late-breaking works, 5 work-in-progress papers, 1 video showcase paper, 5 demo papers, and 2 student game competition papers. This diversity of paper types suggests that Playful HFI is a dynamic research area with a valuable range of approaches and contributions. While exciting, this range demonstrates much early-stage research and presents challenges for analysis, which we discuss in our Findings.

Analysis

To analyse our dataset, we identified relevant coding criteria through the data and looked to HFI [2], play and game design theory [7,11,46,60,63] and previous reviews of play-related HCI [12,61] to ensure our categories were coherent with related research. Coding was performed by the first three authors using a shared Google spreadsheet beginning with 10 criteria, grouped across three dimensions: Meta-data, HFI Lenses and Play-Related Concepts (see:²). To ensure inter-coder reliability, we selected 10 publications across the range of publication-types and venues and independently coded this data. We did not track individual coder activity but can show 41 codes in the original database². We discussed discrepancies and negotiated a common approach. The remaining publications were divided into three sets, each coder took responsibility for two sets, to ensure each publication was coded by two different researchers. Author one coded all three sets, to provide an overview. At each round of coding we challenged our criteria to ensure our emerging model was coherent with the data. Once coding was complete, we discussed our findings to ensure the approach was robust, we identified emergent themes and developed our conceptual model. Our aim with this methodology was to: i) characterise the current state of Playful HFI research in a singular conceptual model that we could share to enable researchers to position their work in relation to the field; ii) identify emerging challenges for Playful HFI and iii) opportunities for future research at the intersection of play, technology and food. The following section details our conceptual model.

THREE DIMENSIONS FOR PLAYFUL HFI

The three dimensions of our model are: Meta-data, HFI Lenses and Play-related Concepts. These dimensions identify commonalities across playful HFI. Each has different criteria, understood as follows (see Table 1 for a visual representation):

Dimension 1: Meta-data

Meta-data encompasses four analytical Lenses: 1) publication date; 2) venue; 3) publication type; and 4) author keywords.

² The analysed dataset is at: <https://bit.ly/2SgGhey>

Dimension 2: Human-Food Interaction Lenses

This Dimension is concerned with the intersection between food, technology and human interaction. It borrows the three analytical Lenses from [2] to categorise HFI works based on their Domain, Focus and Agency. Following [2], we understand and subdivide these Lenses as follows:

1. *Domain*—area of food practice; divided into six Categories: *source*, *store*, *produce*, *eat*, *track*, and *speculate*. These domains were drawn directly from [2]. We challenged them through our thematic analysis and added a seventh category: *reflect*. In the Domain lens, data points can be categorised into more than one Category.
2. *Agency*—to whom or what does the research output (the technology, game or service) attribute agency? Publications are positioned along a continuum between *human empowerment* and *technology automation*, based on authors' stated intention.
3. *Focus*—underlying purpose of the intervention: similar to the lens of *purpose* in [12], or *intent* in [61]. In this lens, publications are positioned along a continuum between *functionality*, *individual experience* and *social bonding*.

Dimension 3: Play-related Concepts

This Dimension is inspired by previous reviews of playful HCI [12,61] and includes three analytical Lenses—

Structure, *Situatedness* and *Experiential Qualities and Textures*—to represent the design qualities of a playful technology.

Structure is inspired by theories on games, play and playfulness [60,63], and reviews of play-related HCI (e.g. the structure lens in [61]). It encompasses three Categories that represent different structures. Data points are positioned in one of the three:

1. *Playful interventions* structured without rules to afford the emergence of free-form playful engagement (e.g. an augmented tablecloth that responds to people's actions [31]).
2. *Open-ended play* structures with semi-ambiguous rules (e.g. a study of how gastronomic experiences could be enhanced through play [3]).
3. *Game-like* structures with clear rules (e.g. a game that promotes healthier snacking habits [59]).

Situatedness is inspired by Salen and Zimmerman's [60] design-oriented use of Huizinga's magic circle of play [37]. While possibly obsolete from a theoretical perspective [20], the magic circle concept is useful from a design perspective as it enables us to characterise the interplay between play and situated activity. Situatedness has three discrete Categories. Data points are positioned in one of the three:


CONCEPTUAL MODEL												
DIMENSIONS		META-DATA		HUMAN-FOOD INTERACTION LENSES			PLAY-RELATED CONCEPTS					
LENSES	Publication date		Agency	Focus	Domain	Structure	Situatedness	Experiential Qualities (grouped into Textures)				
	Venue											
	Publication type											
	Author's keywords											
CATEGORIES			Human	Functionality	Source	Playful intervention (without rules)	Autotelic magic circle	HARD FUN				
					Store			Open-ended play (with rules)	Porous magic circle	Challenge, Completion, Control, Suffering, Thrill, (Hard) Competition, (Hard) Cruelty		
					Produce					SOCIAL FUN		
					Eat					Fellowship, Nurture, Humor, Sympathy, Eroticism, (Social) Competition, (Social) Cruelty		
					Track	CREATIVE FUN						
					Speculate	Fantasy, Simulation, Expression, Subversion						
					Reflect	Game-like structure	Augmented situated activity			RELAXED FUN		
										Submission, Captivation, Sensation		
										EXPLORATIVE FUN		
										Exploration, Discovery		
				Technology	Social experience							

Table 1. Our conceptual model: Three dimensions, with different analytical lenses and categories.

1. *Autotelic magic circle*—where the play activity is dissociated from any situated food practice (e.g. chewing is used as an input to trigger game events, regardless of the meaning the chewing action may have outside the game [6]).
2. *Porous magic circle*—where the play activity is partially associated, and at times intertwines organically, with situated food practices, whether supporting, ignoring, or disrupting those practices (e.g. a robotic arm feeds a player based on their dining partner's affective response, to engender unpredictable, playful social interactions [51]).
3. *Playful (or gameful) augmentation*—where the play is fully associated with the situated food practices. (e.g. a smart bin that leverages social play to promote responsible food waste behaviors [1]).

Experiential Qualities and Textures—the third and final analytical Lens—is inspired by the engagement lens in [61] and playful approaches proposed in [68]. The 23 qualities (see Table 1, right-hand column) refer to the experience the research intends to engender, or the types of experience being studied. They include 21 forms of play identified in the *PLEX framework* [7], with *Competition* and *Cruelty* appearing twice, making the total 23. The Qualities are clustered into five *Experiential Textures*, inspired by widely accepted taxonomies of play and playful experiences: Lazzaro's *4 Keys to Fun* [46], and Caillois' taxonomy of games [11]. The Textures—*Hard Fun* (status-motivated experiences), *Social Fun* (experiences motivated by social connection), *Creative Fun*, *Relaxed Fun*, and *Explorative Fun*—provide an additional layer of organisation to the Qualities, to assist meaning-making. For this Lens, data points are placed in as many categories as needed.

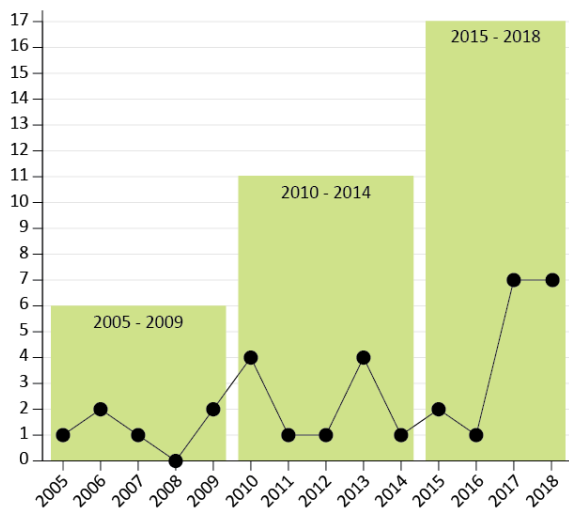


Figure 1. Publications per Year, clustered in 5-year periods. The latest cluster, 2015–2018, is a 4-year period.

FINDINGS

Here, we describe the findings from our analysis across the three Dimensions: *Meta-data*, *Human-Food Interaction Lenses*, and *Play-related Concepts*. For the *Meta-data* analysis, we included all the publications in our dataset—stand-alone projects, publications that describe different stages of a single project, and review articles—despite some repetition in research goals and agenda. We did this as removal of the repetition would disrupt analysis of the amount publications per year, the distribution of research across different venues, and the different formats of publication. In contrast, in the HFI and Play Dimensions we did not include repetitions or review papers, because including multiple publications related to the same research idea would impact our analysis of agendas and findings. We provide further detail in the subsections below, as relevant.

Dimension 1: Meta-data

Publication Year

The publications in our dataset were published 2005–2018. On a yearly basis, we see spikes in publication numbers in 2006, 2010, 2013, 2017, 2018. If we reduce the granularity of the data to five year increments these spikes translate into a consistent incremental increase in publications, from: 6 in 2005–2009; to 11 in 2010–2014; to 17 for the four years from 2015–2018 (Figure 1). While the choice of 5-year increments is somewhat random, it makes visible a growth trend that mirrors what we see in HFI research [2].

Publication Venue

Publications are disseminated across 17 venues (Figure 2). CHI Play is the most important with 9 publications, followed by CHI, with 5. The majority of publications (28 of 34) are from HCI-related venues: general HCI (9 publications), play-oriented HCI (9), interaction design (7), engineering (3). The remaining publications are disseminated across computer

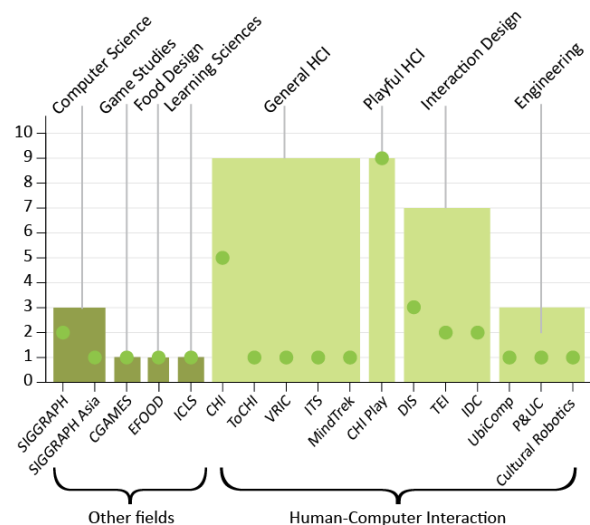


Figure 2. Publications per Venue, clustered by field.

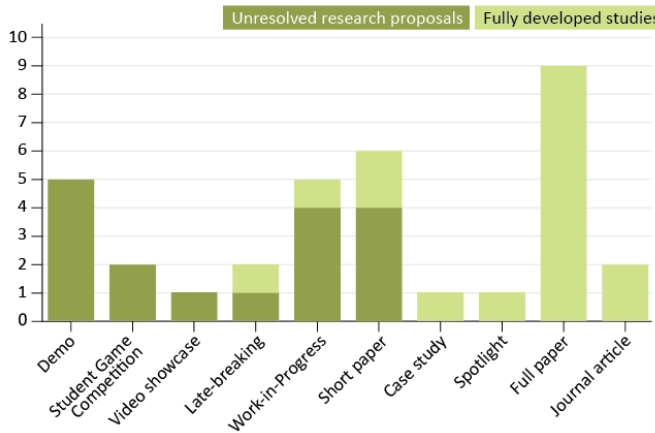


Figure 3. Publications per *Type*, divided into partially developed (olive green) and fully-developed (light green) studies.

graphics (3), food design (1), game studies (1), and learning sciences (1).

Type of Publication

Our dataset includes 10 publication formats (Figure 3): journal articles (2), full conference papers (9), spotlight papers (1), case studies (1), short papers (6), works-in-progress (5), late-breaking works (2), video showcase papers (1), student game competition entries (2), and demo papers (5). Of those, 17 publications report fully developed research studies. For example, Glasemann et al.'s design and evaluation of a game to teach healthier eating habits to young children with diabetes [33]; or Mehta et al.'s exploration of a social robot that mediates eating encounters [51]. The other 17 publications are less developed, i.e. they lack a robust validation mechanism such as a user study or do not present clear, novel or significant findings. For example, Coelho's demo paper that describes (but does not evaluate) *DinnerWare*, a set of dining utensils augmented with electronics [17]; or Altarriba Bertran et al.'s playful food waste bin mock-up [1]. Our evaluation of the significance of contribution is not tied to paper length or type. Some short contributions (works-in-progress, late-breaking works, or short papers), for example, present fully-developed contributions and report significant findings, e.g. Mueller's review of three playful eating technologies [55].

Author Keywords

We analysed author keywords across all publications. The most used keywords are: *food* (22), *games* (18), *design* (11), *interaction* (10), *eating* (8), *game* (7), *play* (7), and *health* (7). From this initial sort we grouped keywords as game-related, play-related, or playfulness-related—three concepts commonly used in play theory and design to differentiate types of play artifacts (e.g. [60,63]) (Figure 4). These categories enable us to analyse how authors frame their research in terms of play structure. Our results show a clear dominance of game-related keywords (29): *games* (18), *game* (7), *gaming* (1), *gamification* (1), *gamer* (1), and *advergames* (1). Play-related keywords (7) include: *play* (6)

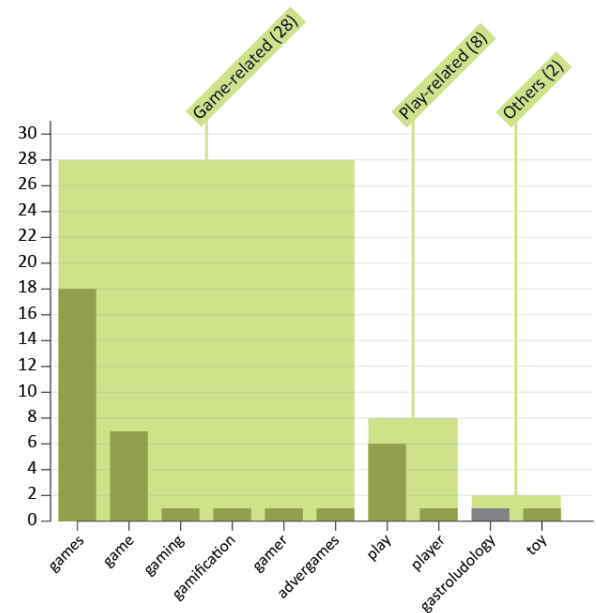


Figure 4. Spread of *Author keywords* in the dataset.

and *player* (1). Additional keywords—*gastroludology* (1) and *toy* (1)—were determined as sitting between play and playfulness. No publications in the dataset used *fun* or *playfulness* as a keyword.

Dimension 2: Human-Food Interaction Lenses

For this Dimension we removed publications that reported initial stages of projects that led to more developed contributions: [5,10,17]. We also removed publications that reviewed projects otherwise included in the dataset: [13,55]. We analyse the remaining 29 publications through the Lenses of *Domain*, *Agency*, and *Focus*.

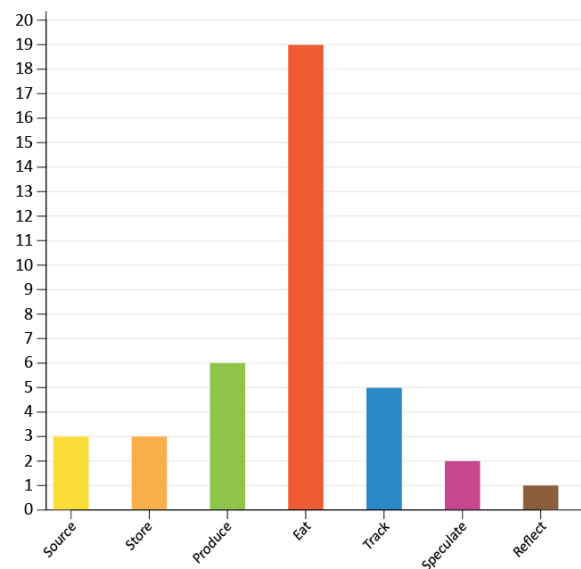


Figure 5. Publications across the six *Domains* of food practice identified in [2] plus 'Reflect'.

Domain

All domains of food practice are addressed in our dataset (Figure 5), though two-thirds focus on *eating* practices (19 of 29). For example, Arza et al.'s augmented reality game to encourage children to chew their food better [8]. Food *production* is next in significance (6), e.g. Ibáñez's system for children to create digital games by taking pictures of the food they prepare [38]; and *tracking* (5), e.g. Glasemann et al.'s game to teach children with diabetes to better manage their eating behavior [33]. These are followed by *sourcing* (3), e.g. Bomfim and Wallace's game that teaches food literacy through shopping [9]; and *storing* (3), e.g. MacNamee's game that teaches safe food storage measures to student chefs [50]. *Speculative* Playful HFI works are residual in the dataset, with only two entries: Li et al.'s ingestible sensor game [48], and Moser and Tscheligi's study of the potential of taste as an input/output system in interactive experiences [54]. We did not observe significant changes in trends in the data over time. We found one publication that did not fit the categories borrowed from [2]: an investigation of playful engagement with food materials as a platform for science education [16]. Recognising that using food to afford and shape reflection differs from other HFI engagements, we added the category *Reflect* to the domain lens (Figure 5).

Agency

Figure 6 shows different approaches to *agency* embraced by the publications in the dataset. The most common type being *empowering humans* to engage in food practices by themselves (15). For example, Kosaka and Iwamoto's game that teaches healthy eating habits [42], or Wang et al.'s system that allows people to play music by interacting with food [66]. Slightly fewer publications discuss technology interventions where human empowerment and technology automation are in balance (13). For example, Echtler and Wimmer's system to project interactive interfaces on top of a table [25], or Ibáñez's software that builds game levels

resembling the shapes in photos of food [38]. Only one publication drives food practices with *technology*: Arnold et al.'s virtual reality game where the player needs to chew food when the game asks, if they wish to stay alive in the game [6]. We observed no change in trends in the approaches to agency over time.

Focus

Figure 7 shows the focus of each research contribution: *Functionality*, *Individual Experience* or *Social Bonding*. Most dominant are *functionality-focused* works that explore the potential of Playful HFI interventions as means to achieve utilitarian goals (15). The majority of these focus on educating people about food-related practices, for example, Park et al.'s game to promote healthy choices of snacks [59], or Orji et al.'s game for long-term dietary behaviour-change [58]. Works that focus on supporting *social bonding* around food practices are less common (7). For example, Mehta et al.'s robotic arm that promotes social interaction between diners [51], or Altarriba and Wilde's experiments with enhancing gastronomy in playful and social ways [3,68]. Works that enhance the *individual experience* of engaging in food practices are also less recurrent (7). For example, Wang et al.'s system to play music by interacting with food materials [66], or Moser and Tscheligi's study of taste as a potential input/output mechanism in interactive systems [54]. If we combine *Social Bonding* (7) and *Individual Experience* (6), we find that a focus on experience (13) is almost on a par with functionality-directed works (15). We found no significant changes in these data trends over time.

Dimension 3: Play-Related Concepts

For this Lens, we excluded repetitions and review papers to avoid misrepresenting the data. The criteria considered are *Structure*, *Situatedness*, and *Experiential Qualities and Textures*. These concepts encompass all of the data and, as discussed below, reflect existing theory and literature.

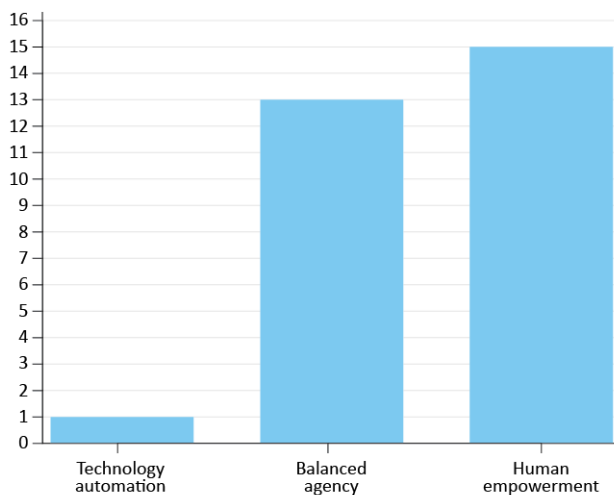


Figure 4. Publications clustered to show where *Agency* is attributed (from tech automation to human empowerment).

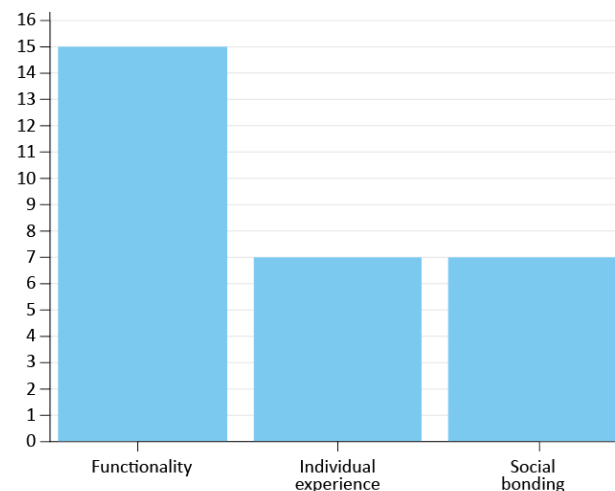


Figure 5. Publications clustered according to the dominant *Focus* of the Playful HFI interventions.

Structure

Figure 8 shows the types of play structures discussed. We found a high presence of works with a focus on *game-like* structures that make use of traditional game elements and robust sets of rules (14). For example, Grimes et al.'s game in which players learn to make healthier food choices [35], or Mac Namee et al.'s game to teach kitchen safety [50]. *Open-ended play interventions* with a looser structure and set of rules are in the minority (6). Examples include: Linehan et al.'s social tagging system to encourage healthier eating, and Mehta's robotic arm that mediates interactions between diners [51]. *Playful interventions* without pre-set rules (9) are also less dominant, e.g. Arakawa and Inakage's system that enhances dining experiences by reacting to people's eating interactions and projecting visual output on the table [4]. Again, we observed no changes in the data trends over time.

The colour distributions in Figure 8 visualise the correlation between the *structure* and *focus* lenses (focus is detailed in Figure 7). Game-like structures tend to focus on functionality in response to utilitarian goals. Whereas, playful interventions focus more on promoting individual experiences of food practices and, to a lesser extent, social bonding. In open-ended play interventions with looser rule-sets we note a relative balance between functionality and social, with little focus brought to individual experience.

Situatedness

Figure 9 shows the intersection between the proposed play activities and the situated food practices they address. The most common types of interventions discuss the design of an *autotelic magic circle of play* where the play activity is dissociated from any situated food practice. For example, Bomfim and Wallace's grocery shopping simulation game [9]. Autotelic play activities are followed closely in number by those that propose a *porous magic circle*, where the play activity is partially associated, and at times intertwines organically, with situated food practices (10). For example, Wei et al.'s 3D printing intervention allows people to design and print food as a form of interpersonal communication

[67]. Finally, least common, we find *augmented activities*—where the play is fully associated with the situated food practice (8). For example, Arza et al.'s augmented reality game adds a layer of narrative to eating to promote longer chewing [8], or Murer et al.'s playful interactive lollipop serves as a haptic input device and dynamically changes its taste qualities in response to user engagement [56]. Again, we observed no changes in data trends over time.

If we compare our findings in the *situatedness* lens with those in *focus* (Figure 9), we find that Playful HFI interventions with an autotelic magic circle often have utilitarian agendas, e.g. educating or changing people's behavior. This is also true for interventions that augment situated food practices with some element of play. In contrast, interventions that present a porous magic circle—where the play activity is partially associated with, and at times intertwines organically with, situated food practices—seem to focus more on improving individual or social experiences of these food practices, without expecting pragmatic or productive outcomes from the intervention.

Experiential Qualities and Textures

Figure 10 shows the distribution of types of playful experiences, examining the *experiential textures* used to craft the Playful HFI interventions. These textures represent the key types of fun that characterise each play experience. Interventions that propose experiences based on *Hard Fun* clearly dominate (12), e.g. challenge-based serious games [42,58,59]. Significantly less dominant are *Social Fun* (5), e.g. Mehta et al.'s robotic arm mediates people's eating encounters [51]; *Explorative Fun* (5), e.g. Gaver et al.'s augmented tablecloth that stores and ambiguously displays the presence of previous objects [31]; and *Creative Fun* (4), e.g. Coelho's augmented dinnerware [18]. *Relaxed Fun* (2), e.g. Echter's table projection system [25], is least present. We observed no noticeable changes in these data trends.

We considered how the textures relate to the type of play structure described (Figure 10) and found that all publications with a focus on *Hard Fun* present a game-like

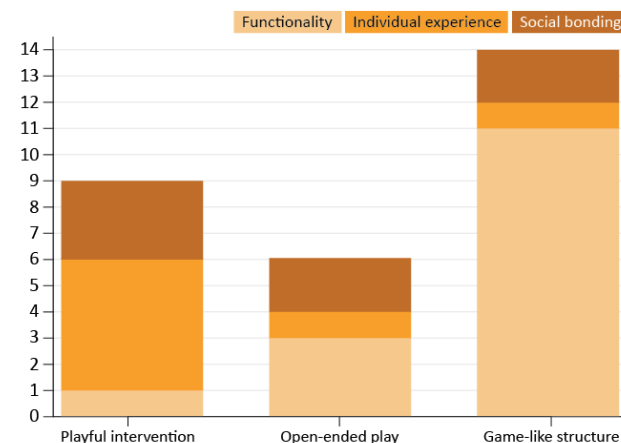


Figure 6. Publications clustered according to *Play structure* (Playful, Open-ended, Game-like), cross-referenced with *Focus* (Functionality, Individual experience or Social bonding).

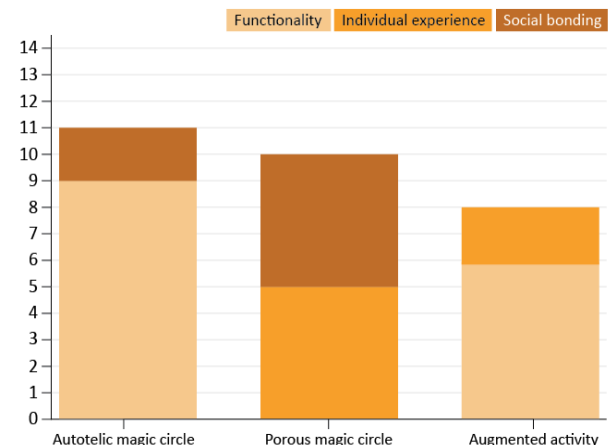


Figure 7. Publications clustered according to *Situatedness*: the interplay between the play activity and food practice, cross-referenced with the *Focus* of the intervention.



Figure 8. Publications clustered according to *Experiential texture*, cross-referenced with type of *Play structure*

structure; most publications focused on *Social Fun* present open-ended play structures; and the dominant structure in *Creative*, *Relaxed* and *Explorative Fun*-focused interventions are playful with no pre-determined rules.

Figure 11 provides a more granular analysis of the *experiential qualities and textures* of the play interventions, to bring focus to the individual qualities. We find that all publications have multiple experiential qualities, often from different experiential textures. Nonetheless, a quantitative analysis of the experiential qualities in our dataset gave similar results to our qualitative analysis of the experiential textures of the publications: those associated with *Hard Fun* are the most recurrent (70), followed by *Creative Fun* (35), *Explorative Fun* (32), *Social Fun* (28), and *Relaxed Fun* (24). Three of the most recurrent five are sub-components of *Hard Fun*: *challenge* (18), *control* (18), and *completion* (18). The others belong to *Social* (*fellowship*, 13 entries) and *Explorative Fun* (*discovery*, 19). Among the least present experiential qualities are *suffering* (4), *nurture* (4), *social*

cruelty (4), *fantasy* (4), and *eroticism* (2). Only one experiential quality has zero entries: *hard cruelty*. We found a remarkable difference in the occurrence of the most and least used qualities, e.g. *discovery* (19) is used 9.5 times more than *eroticism* (2), or 4.75 times more than *fantasy* (4).

DISCUSSION

The State of Play in Human-Food Interaction Research

Our analysis of Playful HFI publications indicates some resemblances with the state of the art in Human-Food Interaction research as a whole. For example, we saw a trend of increasing growth in Playful HFI publications per year comparable to that identified in the broader space of HFI [2]. We found similarities in the dominant foci of HFI and Playful HFI publications: in both cases, the most common research agenda is supporting functionality, or a productive goal. However, we also note that in Playful HFI, experience-focused works have a slight tendency towards facilitating social bonding around food, rather than enhancing the individual experience of a food practice. While the difference is subtle, it may indicate a particular trait of Playful HFI. In HFI more broadly, social bonding through food practices is the least recurrent research agenda [2].

We observed other differences between Playful HFI and HFI research as a whole. For example, Playful HFI has mostly focused on eating. This is not the case for Human-Food Interaction as a whole: where production (37%), eating (30%) and tracking (23%) share importance [2]. Another defining trait of Playful HFI as opposed to HFI is the way that researchers focus on agency. Most Playful HFI interventions afford the human at least as much impact on the unfolding of the activity as the technology. Indeed, the human often leads the data input and control process. In contrast, in HFI as a whole 52% of publications explore interventions based on technology automation [2]. This difference may be due to the inherently interactive nature of playful experiences.

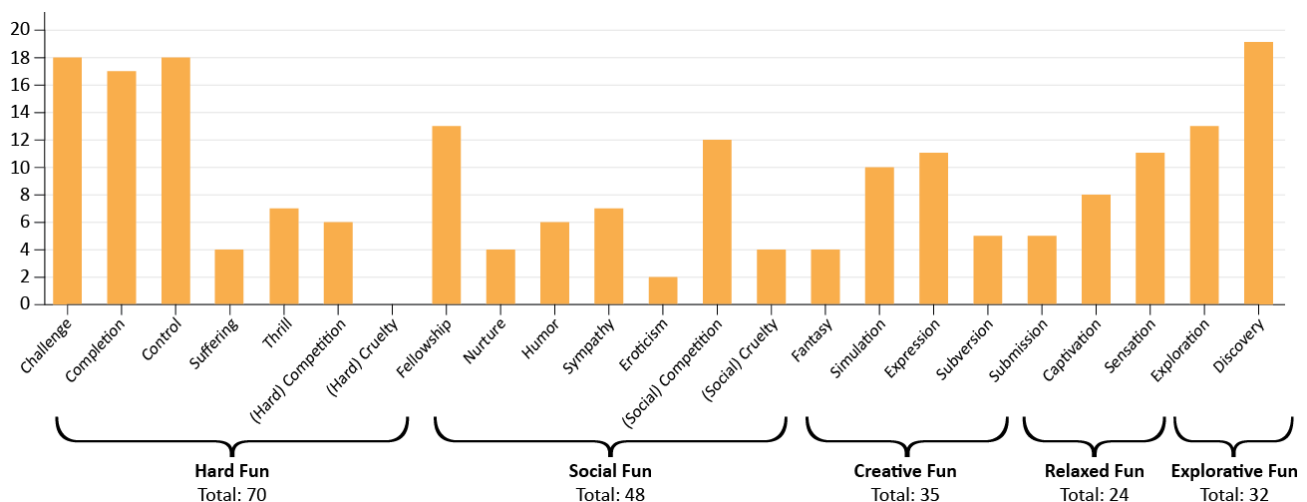


Figure 9. Publications clustered into each *Experiential quality* grouped in their *Experiential textures*.

When looking at our dataset from the perspective of play concepts, we surfaced a series of findings that might help characterize the research space of Playful HFI. We found a clear dominance of works that present a game-like structure—that is, a play structure that is bounded and supported by a robust set of rules. Publications that explore interventions with more open-ended forms of play, especially those that study playful experiences without clear rules or boundaries, are significantly less present in our dataset. When looking at the interplay between the play structure and the supported food practice, we found more equilibrium between the different approaches: the number of works that present an autotelic magic circle, a porous one, or that simply augment a food activity (with no magic circle) are quite similar.

We also see a clear pattern in the experiential qualities and textures. With most data points, the dominant experiential texture is Hard Fun; Social, Explorative and Creative Fun come second, and Relaxed Fun is residual. We saw a correlation between dominant experiential textures and types of play structure, where Hard Fun experiences were mostly afforded by interventions with a game-like structure, often motivated by a utilitarian agenda.

These trends help characterize the state of Playful HFI: we see a clear focus on eating and drinking, with little consideration of other food domains such as sourcing, storing and producing food, tracking food and food-related activities, speculating food futures, or using food as a material practice to support thinking and learning. Playful HFI interventions tend to promote user empowerment, as opposed to technology automation; they often employ game-like structures with clear and robust rules and tend to focus on affording experiences of Hard Fun (e.g. competition, task completion, etc.).

Challenges and Opportunities for Playful HFI

We identified a number of issues around Playful HFI. Most strikingly, under-developed research proposals make up half of the publications in our dataset (17 out of 34). Among these, two have led to a comprehensive study [5,10] and three have been included in an extended abstract that makes a theoretical contribution [55]. Four others have been published since 2017 [1,8,9,66] and may yet evolve into more comprehensive studies. Even in the hypothetical situation where these recent four works are developed into full studies, the ratio between unresolved works that lead to a larger study and those that do not remains low. Considering their proportional dominance, under-developed research studies contribute extensively to Playful HFI. While we should be wary of making over-inflated claims about this fledgling research area based on anecdotal contributions, we suggest it is important to reflect upon the role such contributions might play in an emerging research area. We propose consideration of how anecdotal, partially-developed interventions might lead to rigorous, fully-developed studies and theoretical contributions, moving forward.

Another aspect of Playful HFI that stands out in our analysis is the imbalance in explored domains. Most Playful HFI research is focused on eating or drinking. We see a huge opportunity to broaden the scope of research, to explore how play and playfulness can add value to other food practices. Altarriba Bertran, Wilde, et al. identified a strong trend in HFI to use technology to automate food processes and detract humans from the activity loop [2]. We wonder if more playful approaches to HFI across the spectrum of domains of activity, might afford development of technologies that bring us closer to our food practices, in all of their richness. The results could render not only consuming food exciting, social and fun, but also sourcing, storing, producing, tracking, speculating and learning through it.

Similar to HFI, in Playful HFI, across all domains, functionality-focused works tend to dominate. Rather than focusing on how play can be used to solve problems, we propose that more focus could be brought to other ways that play can make life worth living. We acknowledge the potential of play to support productive agendas, but also see an opportunity to leverage what John Cage calls “the purposeful purposelessness” of play, as “an affirmation of life—not an attempt to bring order out of chaos nor to suggest improvements in creation, but simply a way of waking up to the very life we're living” [43]. As William Gaver reminds us: ludic design can support values such as curiosity, play, exploration and reflection, which are not only important, but are essential to wellbeing [31].

Most education-oriented works in our dataset focus on playing *about* food, not playing *with* food: using virtual simulation. Given the embodied nature and importance of materiality in food practices, this tendency seems to overlook important experiential values, values long recognised as intrinsic to play [41,47,63]. Arza et al.'s game that augments real chewing processes through AR projections [8] might be considered an inspirational concept that moves towards playing with food directly.

Another issue we found in Playful HFI is an imbalance in the types of play *structures* used. We note a heavy focus on game-like structures with robust rulesets and boundaries. This imbalance presents a conundrum. Food practices are often remarkably fluid, emergent and situated—the ongoing activity changes as people interact with and through their food. Rigid game structures may not be suited to fully embrace such flexibility.

Further, the data demonstrates that game-like HFI interventions tend to embrace a narrow set of playful *experiences*: the majority focus on Hard Fun. This narrowness is a clear limitation. Sharp and Thomas caution designers to be wary of “an aesthetics of meaningful choice”, which limits play structure to play-as-reward or play-as-progress [62] and in turn “limit[s] our ability to experience or make sense of other flavours of fun” [62]. Feminist scholars, discussing game design in industry, similarly stress a need to enlarge approaches to game design [27,28].

We invite HFI researchers to consider the breadth of the experiential qualities and textures included in our conceptual model (Table 1, right-hand column). We hope the richness of this list might inspire researchers—as it has us—to explore more open-ended play experiences and playful interventions without clear rules in preference to more recognisable game-like structures, and discover new ways of designing Playful HFI. Other opportunities to expand Playful HFI include inviting experts from different fields to engage in development, e.g. Developing new forms of food-oriented participation [68]; bringing student chefs and game designers together [68]; developing new tools for making food-based materials [13]; and looking to new and emerging technologies for opportunities to develop play, for example, bringing AI in as a creative partner.

CONCLUSION

We reviewed the state of the art of Playful Human-Food Interaction research through December 2018. Our review offers a critical reflection on the evolution of the field and brings to light challenges and opportunities emerging at the intersection of technology, play and food. To conduct the review, we developed a conceptual model of Playful HFI that affords analysis through three dimensions: Meta-data, Human-Food Interaction Lenses, and Play Concepts. We believe this conceptual model will enable researchers to enrich their foci in the field of Playful HFI.

In conducting our review, we found resemblances with the development of HFI research as a whole, e.g. a trend of incremental growth. We found areas where Playful HFI differs from HFI, such as its focus on supporting social, rather than individual, experiences. Our review also surfaced challenges in Playful HFI research: slightly more than half of the publications in our dataset discuss studies that lack a robust evaluation mechanism or clear and significant findings; and: Playful HFI research often uses play to support productivity-related agendas—sometimes to the detriment of exploring opportunities to leverage play for its own sake and make food practices more social, exciting and fun.

We identified diverse opportunities for future research in Playful HFI, including: embracing materiality and embodiment as key aspects of food—in particular food education—interventions; diversifying types of play structures and intended experiential qualities employed—to transcend the current dominance of Hard Fun in interventions; and exploring other areas of food practice than eating and drinking. We hope these findings will inspire Playful HFI scholars to pursue new lines of research in this exciting field, and that it will empower them to better position—and critically reflect on—their work.

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