Tasty Tech: human-food interaction and multimodal interfaces

Merijn Bruijnes
University of Twente
Enschede, the Netherlands
m.bruijnes@utwente.nl

Gijs Huisman
University of Twente
Enschede, the Netherlands
gijs.huisman@utwente.nl

Dirk Heylen
University of Twente
Enschede, the Netherlands
d.k.j.heylen@utwente.nl

ABSTRACT

The perception of food involves, not just taste, but all senses. We describe several interactive and novel mixed reality systems designed to enhance or change a dining experience by using computer generated visual, audio, and tactile stimuli. We describe how ideas from these playful designs can influence the perception of, and the interaction with food, and can inform the design of studies into human-food interaction.

Categories and Subject Descriptors

H.5.1. [**Information Interfaces and Presentation (e.g. HCI)**]: Artificial, augmented, and virtual realities

Keywords

Mixed reality technology; Multimodal flavour perception; Technological Cuisine; Projection mapping

1. INTRODUCTION

Research has shown that all of the senses contribute to the perception of flavour [2, 5, 30, 37]. A clear example of the influence of other senses on the perception of flavour is the popular maxim 'we eat with our eyes first' [6]. Indeed visual impressions of food drive expectations of what the food will taste like, and can influence the actual taste [6, 19, 39]. In addition, the sounds that are audible while chewing can make a crisp seem either fresh or stale [17], and even certain musical compositions can affect the perception of certain tastes, such as sweetness or bitterness, in chocolate [26]. Not only that, but the weight of a piece of cutlery [11] can affect how people perceive the food consumed from such a utensil.

The notion that flavour is a multi-sensory percept has been exploited in modernist restaurants that typically aim to stimulate all the diners' senses [33], and has thus inspired creative and novel dishes by famous chefs. For example, in the 'Sounds of the Sea' dish, served at The Fat Duck restaurant, a seafood dish is accompanied by an MP3-player that plays ocean sounds, purportedly transporting diners to the seaside [33]. This not only underlines the multi-sensory nature of flavour, but also indicates another opportunity: the use of technology to influence food experiences.

The combination of food and technology can be interesting for the introduction of stimuli that may be difficult to introduce in a dining environment otherwise. Here, there are clear opportunities for the use of mixed reality technology, which can introduce digital elements into the real world [22]. This combination of mixed reality technology and food is especially tantalizing because it allows for digital cues to be presented in combination with actual food items. The use of digital visual cues, for example, could allow for visual enhancements of food items in order to make them look more appealing, tasteful, or interesting [32]. Projection mapping, a technique where projections are adjusted to exactly fit an area of projection, can be used to alter the colour of a food item, the colour and shape of the setting in which the food item is presented [32], and could even be used to project animations onto the food [16].

Sensor technology combined with computation and various outputs, be they visual, auditory, or tactile, can also allow for interesting, useful, or novel human-food interactions. Technology that monitors the food intake as well as the eating speed of diners is for example already being used for monitoring a persons eating habits [12]. Nevertheless, the same technology could be used to for example alter projections, and music, creating rich multi-modal eating environments that have the potential to enhance a person's experience with food.

In this paper we present a number of student projects that were created with the idea of introducing multi-modal interfaces into the dining experience. We will discuss these installations based on a categorization of approaches to multi-modal interfaces in human-food interaction that was identified in the literature. We outline the ideas behind these installations as well as their general design, and we will discuss public reactions to these installations gathered during an informal event. We will show how these installations can not only offer interesting human-food interactions, but could also serve to inform the design of studies into the perception of flavour.

2. RELATED WORK

The use of multi-modal technology in combination with food, begs the question of exactly how technology can be used to enhance the experience of food. To provide a tentative answer to this question we conducted a literature study [1] of which a selection is listed below, and held discussions with experts from leading food companies. Using these methods, we identified five approaches for the use of technology to enhance food experiences:

- **Technology with food as the medium**: with aid of technology, food itself can be used as a medium, for example as a way to display data [15], or for communication purposes [21].

MHFI'16, November 16 2016, Tokyo, Japan

DOI: http://dx.doi.org/10.1145/3007577.3007581

- **Technology and cooking/dining rituals**: technology can be introduced into the rituals that surround the preparation and the consumption of food at the dinner table. For example, dining together in remote locations using technology for telepresence [38], using augmented reality to teach cooking skills [20], and making the act of cooking more fun and enjoyable through augmented appliances [9]. Many of the works found in this area are aimed at existing social structures, such as family dinner time [29].

- **Technology to change eating behaviour**: by leveraging the measurement capabilities and interactive nature of mixed reality technology, interventions can be created with the goal of changing eating behaviours. Here, there is an almost exclusive focus on healthier eating behaviours. Three subcategories can be distinguished, namely: teaching basic good eating habits to children [7], behaviour change for healthy eating in general, such as eating more slowly [14], and technology used to change eating behaviour in a clinical setting, such as treating obesity [3].

- **Technology to change flavour experiences**: inspired by findings from research on cross-modal perception, technology can be used to augment the way the flavour of actual food items is experience. For example using top-down projection techniques to enhance colour saturation of food [16], or augmenting the sound of chewing the change food texture perceptions [17], both which can influence the taste of the food.

- **Technology to simulate flavour**: technology can be used to fully simulate eating or drinking, without actual consumption of food items. An example is a digital taste simulator using electrodes placed on the tongue that can produce mint or lemon flavours [25].

The approaches listed above should help researchers and professionals think about ways in which technology can be used for enhancing food experiences. Technology can enable food itself to become an expressive medium, and can help to maintain social structures surrounding the preparation and consumption of food. Mixed reality technology can be a powerful tool to help people eat healthier, and might help to combat food related health issues. Technology can be used to enhance the flavour of food, making modernist restaurants an interesting application area, where perhaps in the future we may experiences flavours without the presence of any actual food!

3. INSTALLATIONS

The installations we will describe in this section were created by students who followed who followed Media Technology course from the Human Media Interaction masters program and were demonstrated to the general public at a food court[1]. In this section, we will describe *anecdotally* the experiences the guests of Fooddock had with the installations and what implications this has for designing mixed reality installations for food. These anecdotes are based on the observations of the authors.

3.1 Experience Dining: Ørbit

The Ørbit installation delivered a unique experience using storytelling, molecular cooking, and a nice design. It featured a private darkened room with a rotating platform on a table where two guests would sit opposite each other and listen to a story. The middle of the platform had an area where animations were displayed. Several cups holding edible 'orbs' were placed on the rotating platform, see Figure 1. The orbs were created with spherification [23], a molecular cooking technique popularized in 2003 by Ferran Adrià, the legendary chef of El Bulli restaurant. The orbs are flexible spherical membranes surrounding a flavoured liquid that release the flavour at once when pierced in the mouth. When the rotating platform stopped, a light under the cup facing the guest illuminated the orb, inviting the guest to consume it.

Guests took place opposite each other at the table and put on head phones. The setting of the story was a blind date in a bar. Each guest heard their version of the story through a first person perspective interior monologue, specifically a stream-of-consciousness narrative voice. The voice was intended as the guest's own thoughts. The voice gave comments about the history leading up to the blind date, the situation, the restaurant, the food and drinks, and the date (who is 'played' by the other guest). During the story there were moments where the voice, or the date, ordered food or a beverage and these moments were synchronised in the story of both guests. At such a moment the platform stopped rotating and the orb that represents the food or drink item that fits the story at that moment faced the guests and was illuminated. The projection on the platform fitted the food or beverage with an animation of colour and shape [27, 10]. After consumption, the platform restarted rotating and the story continued. There were two versions of the story: a good date and a bad date. The progress of the story was driven by the interior voice's desire to please the other to get a follow-up date in the good date condition, or to get out without hurting the other's feeling in the bad date condition. Both versions of the story followed a similar pattern, in ordering food items and provoking guests' behaviour, but differed on the mood and frame of mind. Also there were gender specific versions of the story where the voice actor is male or female to fit the gender of the guests. The duration of the experience was 6 minutes. The reception of the Ørbit installation was overwhelmingly positive. Guests recommended it to peers, there was a line, interest exceeded the amount of orbs that were prepared, and guests often inquired when and where the installation would be showed again.

Story-telling techniques and using a narrative voice allowed us to change the mood of the user and to investigate whether the mood of the user influenced the perception and experience of flavours.

Figure 1: The Ørbit installation. The each cup holds an orb: a spherified liquid.

3.2 Playful Dining: Hunger Games

The Hunger Games installation featured a dining table that emphasised the social aspect of having dinner together by creating a shared challenge. The plate of each guest was placed in an aperture in the table in front of the guest, see Figure 2. These apertures could be covered with an diaphragm making the plate and the food

[1] http://www.fooddock.nl

on the plate inaccessible. Cutlery was placed on conductive areas next to the aperture, making it possible for the installation to sense whether the cutlery was picked up. When a guest picked up his or her cutlery the system closed a diaphragm: the cutlery controlled the irises that cover the food. The algorithm that determined which plate was covered was unknown to the guests and the rules could change. Guests had to work together, using careful observation and experimentation, to figure out what the relation was between picking up cutlery and the closing of the irises. The installation emphasised the social aspect of having dinner together as only by collaborating all guests could eat.

Introducing a challenge or gaming aspect to a dining installation created positive social interaction. Having a common goal or a shared challenge and being dependent on each other is a good recipe for group creation [34]. Guests who interacted with our Hunger Games installation engaged in enthusiastic conversation and collaboration despite never having met before. This effect was particularly pronounced in a group of children, who seemed to remain in the group that formed at the Hunger Games table while they visited the other installations. Additionally, the installation had an effect on the eating behaviour of some of the guests. Some guests tried to beat the system by very quickly taking the food when the diaphragm started to close.

Figure 2: The Hunger Games installation. The aperture on the left is closing and the aperture on the right is already closed. The conductive sensor that can detect the presence of cutlery can be seen next to the apertures (grey areas).

3.3 Ordering: 'Tinder' for Food & Interactive Tables

Systems where restaurant guests could autonomously order from a digitally presented menu were patented as early as 1985 [18]. This included an entertainment system where patrons could "interactively play a variety of remotely retrievable interactive entertainment activities using the video monitor while waiting for the food to arrive"[18]. While major improvements were made in the area of graphics and interactivity, the underlying concept has remained the same for most systems where guests can autonomously order their food (e.g. [4]). A next step in the ordering process is a system that can make an automatic (pre-)selection of the menu items that fit a guest best. Some items from the menu can be hidden or given a less prominent spot on the menu based on the profile of the guest. For example items that a guest cannot consume due to allergies, does not wish to consume due to convictions, or simply does not like can be hidden. The Foodroulette ordering system presented such a menu based on food preference.

Getting the preferences of a guest is another matter. This was solved by creating an app that followed the interaction paradigm of popular dating apps like Tinder[2]. In such apps the user is presented with a picture of a person of the preferred gender accompanied with a short description. The user can 'swipe' the picture to the right to show interest and to the left to indicate no interest. This paradigm was used in the app Foodroulette. Foodroulette was used to obtain a food preference profile of guests, see Figure 3. A guest could put his or her smartphone with the app on an NFC enabled touch table to upload his or her preferences, see Figure 4. The table then showed a selection of the restaurant's menu where the dishes that the guest might like get a prominent place, see Figure 5. The guest could explore the personalised menu and select a dish through a touch interface. The preparation of the selected dish could be presented on the table, which gave a new meaning to an open kitchen, for example through a live camera feed of the chef preparing the food or a pre-recorded clip, see Figure 6. Additionally, an indication of the remaining waiting time was indicated with a picture of the selected dish that was slowly moving towards the guest on the table.

The ordering process might benefit from interactive tables, especially when combined with automated adaptation of the menu to preference and allergies. However, beyond the novelty effect of flashy designs and smooth interactions with touch tables the added benefit compared to traditional ordering methods was limited. In our opinion such technology should not be intended as a replacement for waiting staff as guests often enjoy the social interaction with the staff.

Figure 3: The smart-phone app Foodroulette.

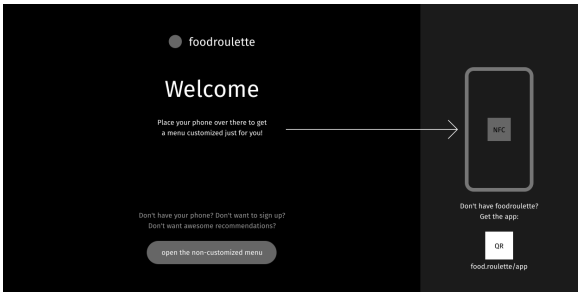

Figure 4: Placing a smart-phone that has the Foodroulette app on an interactive table.

3.4 Behaviour Change Support: Thunder Dinner

[2]www.gotinder.com

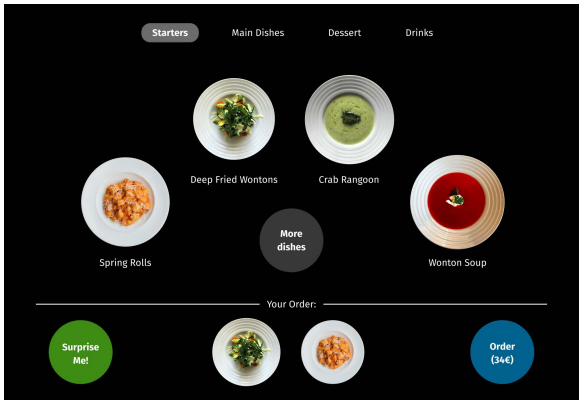

Figure 5: Ordering on an interactive table.

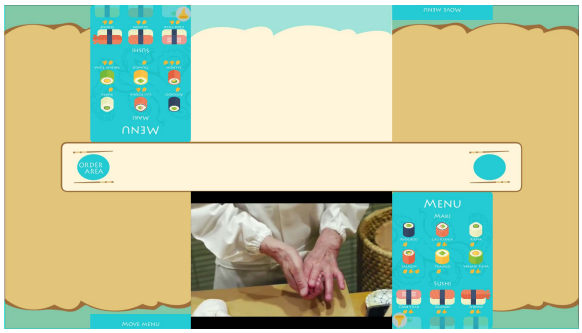

Figure 6: Ordering on an interactive table, visualising the time before the order arrives.

Technology can play an important role in aiding and stimulating healthy eating behaviours. This can take many forms, for example helping disabled people consume food autonomously [35], teaching basic good eating habits to children [7], or eating more slowly [14].

In the Thunder Dinner installation the eating behaviour of the guest was observed, and auditory, visual, and tactile stimuli were used to indicate that the guest was eating too quickly. During the demonstration of the installation guests were invited one at a time in a private room where they were presented with a bowl of soup and a spoon. Unbeknownst to them, they were being observed through a Microsoft Kinect. The Kinect data was combined with the data from an accelerometer embedded in the handle of the spoon to allow the installation to guess the eating speed of the guest. When a guest was eating to fast the illusion of a thunder strike was created by flashing the lights, playing sound of a thunder strike, and vibrating the spoon with an actuator embedded in the handle. The initial effect of the thunder was surprise followed by investigating what triggered the thunder. Some guests lowered their eating frequency to avoid being 'Thundered'. Inadvertently sometimes guests started eating faster to induce the thunder, perhaps to repeat the experience.

The Thunder Dinner is an example of an installation that can be used to change the eating behaviour of a user in a playful manner. However, care should be taken that the stimulus, intended to reduce a behaviour, is not so interesting that it is sought. Alternatively, an interesting stimulus might be used to promote wanted behaviour.

3.5 Tasty Projections: Projection Mapping on Food

Research indicates that visual cues, such as colour and shape, contribute strongly to expectations about taste and taste perception during consumption [8, 13, 24, 28, 31, 36, 11]. For example, the colour of drinks showed consistent colour-flavour associations: red was associated with cherry and strawberry, whereas green was associated with mint and lime [28]. In an installation demonstrated to the general public at 'The Future of High Tech'[3], the guests were asked to select combinations of visualizations and animations to be projected on a cup of yoghurt to make it appear as appealing as possible, see Figure 8. It was suggested guests try to create the sweetest and the most sour projections. Guests could select the properties of the projection from three categories, see Figure 9: shape (rounded or spiked), speed of a pulsating animation (fast, slow, or still), and colour (red, green, or grey).

This installation allowed guests to show what they thought a sweet or sour yoghurt should look like by manipulating its appearance. The yoghurt itself became the medium of this message.

Figure 7: A guest eating soup with the actuated spoon in the Thunder Dinner installation.

Figure 8: The installation where guests could select their preferred 'tasty' projection.

3.6 Research-based Approach: Projection Mapping on Food

Designing recipes, especially in the commercial sector, is a tedious process. To investigate small changes in recipe several batches have to be created and tested in subsequent iterations: a time-consuming and expensive process. Mixed reality technology can address this problem by offering structured and easy examination of effects of colour and animation on certain types of food. In another study we demonstrated associations between taste perceptions and projections. We showed associations between sweetness and

[3]www.thefutureofhightech.com

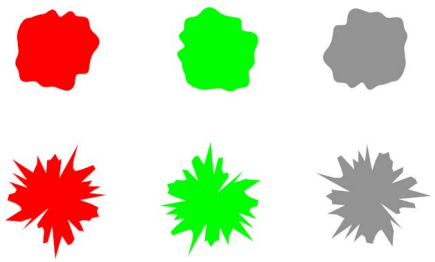

Figure 9: Examples of amorphous shapes that guests could select.

red rounded shapes, and sourness and green angular shapes with a fast animation speed [1]. In that study, the visualizations that were projected around a cup of yoghurt that participants tasted confirmed that specific combinations of visualizations and animation types influence taste perceptions of the yoghurt. In particular, while the colour and shape of the visualizations did not influence taste perception of the yoghurt after tasting, an interaction effect was found that showed that specific combinations of the visualizations with animation type did influence taste perception of the yoghurt. Yoghurt that was presented with a red/rounded still visual was rated as more sour than when presented with a green/angular still, but when the visualization was animated (i.e. fast motion) this effect reversed: when yoghurt was presented with a green/angular animated visual the yoghurt was rated as more sour than when it was presented with a red/round animated visual, see Figure 10. This indicates that projected animations can influence the taste perception of yoghurt, but that the effect depends on the design of the visualizations in terms of their colour and shape. For more details on this study, refer to [1].

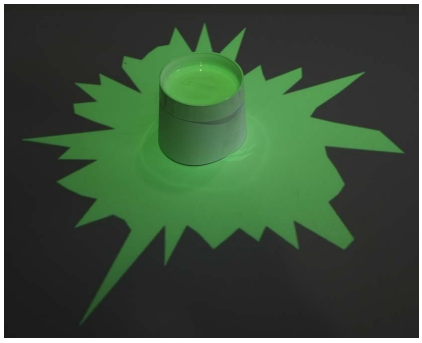

Figure 10: A photo of a projection of a green angular shape on a cup of yoghurt.

4. DISCUSSION AND CONCLUSION

In this paper we discussed installations that used technology to enhance food experience. These installations used technology to change how guests experienced food: by using the food as a medium; by changing the rituals of cooking, ordering, or dining; by changing the eating behaviour; or by changing the flavour experience.

We showed that food can be a medium to display information. In the Ørbit installation, the food conveyed information about a story that the guest was experiencing. In the Tasty Projections installation, the yoghurt became the medium with which guests could convey their message of what they perceived to be an appearance of sweet or sour.

The rituals of cooking, ordering, and dining could be influenced by technology. In the Hunger Games installation the potential awkwardness of dining with strangers was mitigated by creating a shared challenge that required cooperation to solve. Also for familiar diners the installation created a new dining experience. The Foodroulette app and interactive tables changed the ritual of ordering food. In particular, personalised menus based on a guest's food preference and allergies could streamline the ordering process. However, it should be noted that replacing the human waiter with an impersonal system for placing an order makes ordering a less social process. To us it seems very unlikely that this would become a trend in a sector where the difference is made through personal attention and heartfelt hospitality.

Changing the eating behaviour of guests proved possible as seen by the Thunder Dinner installation. However, care should be taken when designing the stimulus that is meant to change the behaviour. We observed that our stimulus, that was meant to be a deterrent for fast eating, was sometimes perceived as interesting or fascinating leading to behaviour intended to trigger the stimulus.

We were able to change the flavour experiences with installations that create cross-modal stimuli. Projecting a coloured animated shape on a food item, in this case yoghurt, changed the taste. The taste of yoghurts that were presented with red/rounded still visuals were rated as more sour than when presented with green/angular stills, but when the visualizations were animated (i.e. fast motion) this effect reversed: when yoghurts were presented with green/angular animated visuals the yoghurts were rated as more sour than when they were presented with red/round animated visuals. Results from our lab study, see [1], showed that mixed reality technology in the form of projection mapping offered unique ways in which the taste perception of food items could be influenced, in this case through carefully designed animated visualizations. The implication is that mixed reality technology can be utilized to systematically investigate taste associations and taste perceptions. This multi-modal approach could not only result in fascinating installations and food experiences, but could also shed further light on the multi-modal perception of flavour.

Acknowledgements

We thank all the students of the Media Technology course at the University of Twente who created the installations. This publication was supported by the Dutch national project COMMIT/.

5. REFERENCES

[1] A. Anonymous, B. Anonymous, and C. Anonymous. A moving feast: Effects of color, shape and animation on taste associations and taste perceptions. In *proceedings of Advances in Computer Entertainment (in press)*, 2016.

[2] M. Auvray and C. Spence. The multisensory perception of flavor. *Consciousness and cognition*, 17(3):1016–1031, 2008.

[3] P. S. Bordnick, B. L. Carter, and A. C. Traylor. What virtual reality research in addictions can tell us about the future of obesity assessment and treatment. *Journal of diabetes science and technology*, 5(2):265–271, 2011.

[4] S. N. Cheong, W. W. Chiew, and W. J. Yap. Design and development of multi-touchable e-restaurant management system. In *Science and Social Research (CSSR), 2010 International Conference on*, pages 680–685. IEEE, 2010.

[5] J. Delwiche. The impact of perceptual interactions on perceived flavor. *Food Quality and preference*, 15(2):137–146, 2004.

[6] J. F. Delwiche. You eat with your eyes first. *Physiology & behavior*, 107(4):502–504, 2012.

[7] S. Ganesh, P. Marshall, Y. Rogers, and K. O'Hara. Foodworks: tackling fussy eating by digitally augmenting children's meals. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*, pages 147–156. ACM, 2014.

[8] L. L. Garber Jr, E. M. Hyatt, and R. G. Starr Jr. Placing food color experimentation into a valid consumer context. *Journal of food products Marketing*, 7(3):3–24, 2001.

[9] V. Halupka, A. Almahr, Y. Pan, and A. D. Cheok. Chop chop: a sound augmented kitchen prototype. In *Advances in Computer Entertainment*, pages 494–497. Springer, 2012.

[10] G. Hanson-Vaux, A. S. Crisinel, and C. Spence. Smelling shapes: Crossmodal correspondences between odors and shapes. *Chemical Senses*, 38(2):161–166, 2013.

[11] V. Harrar and C. Spence. The taste of cutlery: how the taste of food is affected by the weight, size, shape, and colour of the cutlery used to eat it. *Flavour*, 2(1):21, 2013.

[12] S. Hermsen, J. H. Frost, E. Robinson, S. Higgs, M. Mars, and R. C. Hermans. Evaluation of a smart fork to decelerate eating rate. *Journal of the Academy of Nutrition and Dietetics*, 2016.

[13] R. Hurling and R. Shepherd. Eating with your eyes: effect of appearance on expectations of liking. *Appetite*, 41(2):167–174, 2003.

[14] A. Kadomura, C.-Y. Li, Y.-C. Chen, K. Tsukada, I. Siio, and H.-h. Chu. Sensing fork: eating behavior detection utensil and mobile persuasive game. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems*, pages 1551–1556. ACM, 2013.

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

[16] Y. Kita and J. Rekimoto. Spot-Light: Multimodal Projection Mapping on Food. In C. Stephanidis, editor, *HCI International 2013 - Posters' Extended Abstracts: International Conference, HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part II*, pages 652–655. Springer Berlin Heidelberg, 2013.

[17] N. Koizumi, H. Tanaka, Y. Uema, and M. Inami. Chewing Jockey: Augmented Food Texture by Using Sound Based on the Cross-modal Effect. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, 2011.

[18] L. G. Kurland and E. Gilbert. Integrated interactive restaurant communication system for food and entertainment processing, Nov. 12 1985. US Patent 4,553,222.

[19] C. A. Levitan, M. Zampini, R. Li, and C. Spence. Assessing the role of color cues and people's beliefs about color-flavor associations on the discrimination of the flavor of sugar-coated chocolates. *Chemical Senses*, 33(5):415–423, 2008.

[20] S. Mennicken, T. Karrer, P. Russell, and J. Borchers. First-person cooking: a dual-perspective interactive kitchen counter. In *CHI'10 Extended Abstracts on Human Factors in Computing Systems*, pages 3403–3408. ACM, 2010.

[21] H. Nakamura and H. Miyashita. Communication by change in taste. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, pages 1999–2004. ACM, 2011.

[22] Y. Ohta and H. Tamura. *Mixed reality: merging real and virtual worlds*. Springer Publishing Company, Incorporated, 2014.

[23] W. J. S. Peschardt. Manufacture of artificial edible cherries, soft sheets, and the like, July 9 1946. US Patent 2,403,547.

[24] B. Piqueras-Fiszman and C. Spence. Colour, pleasantness, and consumption behaviour within a meal. *Appetite*, 75:165–172, 2014.

[25] N. Ranasinghe, A. Cheok, R. Nakatsu, and E. Y.-L. Do. Simulating the sensation of taste for immersive experiences. In *Proceedings of the 2013 ACM international workshop on Immersive media experiences*, pages 29–34. ACM, 2013.

[26] F. Reinoso Carvalho, R. Van Ee, M. Rychtarikova, A. Touhafi, K. Steenhaut, D. Persoone, C. Spence, and M. Leman. Does music influence the multisensory tasting experience? *Journal of Sensory Studies*, 30(5):404–412, 2015.

[27] H.-S. Seo, A. Arshamian, K. Schemmer, I. Scheer, T. Sander, G. Ritter, and T. Hummel. Cross-modal integration between odors and abstract symbols. *Neuroscience letters*, 478(3):175–178, 2010.

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

[29] M. Snyder, J. Zimmerman, and J. Forlizzi. Your dinner's calling: supporting family dinnertime activities. In *Proceedings of the 2007 conference on Designing pleasurable products and interfaces*, pages 485–489. ACM, 2007.

[30] C. Spence. Multisensory flavour perception. *Current Biology*, 23(9):R365–R369, 2013.

[31] C. Spence, C. A. Levitan, M. U. Shankar, and M. Zampini. Does food color influence taste and flavor perception in humans? *Chemosensory Perception*, 3(1):68–84, 2010.

[32] C. Spence, K. Okajima, A. D. Cheok, O. Petit, and C. Michel. Eating with our eyes: From visual hunger to digital satiation. *Brain and Cognition*, 2015.

[33] C. Spence and B. Piqueras-Fiszman. *The perfect meal: the multisensory science of food and dining*. John Wiley & Sons, 2014.

[34] C. Stangor. *Social groups in action and interaction*. Psychology Press, 2004.

[35] Y. Takahashi, N. Hasegawa, K. Takahashi, and T. Hatakeyama. Human interface using pc display with head pointing device for eating assist robot and emotional evaluation by gsr sensor. In *Robotics and Automation, 2001. Proceedings 2001 ICRA. IEEE International Conference on*, volume 4, pages 3674–3679. IEEE, 2001.

[36] C. Velasco, A. T. Woods, O. Deroy, and C. Spence. Hedonic mediation of the crossmodal correspondence between taste and shape. *Food Quality and Preference*, 41:151–158, 2015.

[37] J. V. Verhagen and L. Engelen. The neurocognitive bases of human multimodal food perception: sensory integration. *Neuroscience & biobehavioral reviews*, 30(5):613–650, 2006.

[38] J. Wei, X. Wang, R. L. Peiris, Y. Choi, X. R. Martinez, R. Tache, J. T. K. V. Koh, V. Halupka, and A. D. Cheok. Codine: an interactive multi-sensory system for remote dining. In *Proceedings of the 13th international conference on Ubiquitous computing*, pages 21–30. ACM, 2011.

[39] M. Zampini, D. Sanabria, N. Phillips, and C. Spence. The multisensory perception of flavor: Assessing the influence of color cues on flavor discrimination responses. *Food Quality and Preference*, 18(7):975–984, 2007.