FoodWorks: Tackling Fussy Eating by Digitally Augmenting Children's Meals

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ABSTRACT
Persuading children to eat healthily can be challenging. Parents and guardians commonly have trouble encouraging young children to eat their vegetables, who often prefer less wholesome alternatives. Parents regularly employ a range of methods that encourage or distract children to eat food they don't want to eat. Digital technologies, such as augmented reality and interactive animations offer new possibilities for enhancing this process. Our research is concerned with how such technology interventions can be used to change behavior in fussy children's eating habits by altering the context of 'playing' with food. FoodWorks was designed to digitally augment a plate of food and provide rewards for completion of the meal. An exploratory in the wild study was conducted using it with 7 families, for children aged between 3-9. The findings were encouraging, providing new insights on social interactions and the effects digital augmentation can have on eating behavior.

Author Keywords
Children, digital augmentation, digitally-enhanced food; persuasive technologies; virtual rewards.

ACM Classification Keywords
H.5.2, K.4.2

INTRODUCTION
Many parents face the daily challenge of getting their children to eat a balanced diet. Meal times can often become a battlefield. Peer pressure and enticing adverts can make sweet treats and junk foods more appealing than healthy, homemade meals. In some cases, children will not eat varied meals, eating the same food, like peanut butter sandwiches, repeatedly, and never touching vegetables. Parents often resort to pretend-play techniques with young children, such as pretending a fork is a plane, and flying it towards the child's mouth in the hope they will open it and eat the food on the fork. Other ways of dealing with fussy eating include hiding vegetables in cakes or renaming food with fun names like 'cowboy chicken' [21].

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Such practical and fun methods can encourage children to be receptive to new foods and make mealtimes a more enjoyable experience for the entire family. In this paper, we are interested in how new digital technologies can extend and build upon these kinds of 'pretend' practices, by developing novel interactive techniques that are both engaging and persuasive. While persuasive technologies have been developed over the last few years to change and motivate a range of behaviors, such as physical activity, sustainability [9, 12, 1, 17] and better teeth cleaning in young children [30], they have not been used, as we do here, in the context of overcoming a child's reluctance to eating certain foods they may dislike. Building on existing persuasive technologies and techniques, we introduce FoodWorks, a system developed to nudge children to eat their vegetables through digital augmentation of the food and the provision of virtual rewards for completing eating targets.

To begin, a number of digital animations were designed to determine which were effective in terms of being attention-grabbing, legible and pleasurable. When tested in a family setting, we wanted to explore how techniques of coloring vegetables and rewarding good behavior would appeal to the children and distract them from their dislike of a food. Following this, a portable prototype (FoodWorks) was built that projected different colors in combination with providing digital rewards on a plate of food, when it was detected that certain vegetables had been removed. A user study was carried out in the homes of a number of families to explore how young children and their parents understood, reacted to and played with FoodWorks during mealtimes. We were particularly interested in exploring the family context and parent-child dynamics in which the system might be used: would FoodWorks encourage parents and siblings to also play a role in nudging children to get over their fussy eating? We discuss the findings in relation to the family mealtime context, focusing on the central role of the social interactions that take place when introducing digital augmentation and virtual rewards to help children overcome their fussy eating.

BACKGROUND
Fussy eating in children is a common and worrying concern faced by many parents. Moreover, given that childhood habits can continue on into adulthood [13], there is an increased importance in encouraging healthy eating habits at an early age. Research into why there is this prevalence

suggests that children often refuse food because of an aversion towards particular textures, smells or temperatures, or even unfamiliarity [26]. Vegetables, in particular, can have strong and bitter tastes combined with soft and mushy textures that can also result in dislike if children are unfamiliar with them. Fussy eating may be overcome through habituation: the more accustomed the child becomes to particular vegetables, the more likely they are to accept them. However, it can be very wearing for parents to help their children get past their obdurate 'refuse to touch' response to disliked food placed on their dinner plate. Our goal was to help parents overcome this impasse by capitalizing on young children's fascination with technology in the home. The idea was to use augmented reality and persuasive technology techniques to make eating disliked food appear more playful and to do so by involving the family in the process.

A key focal point for research in this area is the social context surrounding childhood eating habits. In particular, there has been an emphasis on understanding (i) child-parent relations and their impact on encouraging fussy eating behaviors; and (ii) parenting styles and techniques used to overcome them [16]. Wardle et al [30], for example, showed that a parent-led intervention for children aged between 2-6 holds promise for improving fussy eating. However, in some cases, such interventions may have a negative impact. For example, hiding vegetables in other food can be problematic because it removes responsibility for choice away from the child [24]. Similarly overly controlling parenting styles may have a negative impact on a child's eating behavior. For example, a study showed that when parents over-pressurize their children to eat certain foods, they are likely to resist more [10].

A key benefit of parents getting involved in dealing with their children's food aversions is to provide positive reinforcement for good eating behavior at mealtimes. Studies have shown that when parents use rewards [e.g. 5, 19, 4] to encourage their children to eat certain foods it can facilitate children's acceptance of healthy foods [e.g. 7, 23]. Examples include hugs, tickles and stickers. The use of a board game to encourage young children to increase their repertoire of foods was also found to be effective [11]. Using virtual rewards for good behavior and making things appear attractive through technology [8,15] could also be considered as part of a persuasive strategy.

Recent work has begun to investigate more the 'lived' practices of family mealtimes. Laurier and Wiggins [16], for example, discuss how checks on food completion behaviors are contingent and tailored according to age, family knowledge and other aspects of the remaining meal. In teaching their children how to eat together, the parents and siblings communicate all sorts of additional eating practices such as how to comply appropriately with eating requests.

Other potential approaches are making food appear more aesthetic, palatable and enjoyable in the way it is prepared and presented to children. It is well known that the appearance of food forms an integral part of how we perceive its taste. Zellner et al [32], for example, demonstrated the effects of different food arrangements on their expected taste. The impact of color on eating has been similarly explored, certain colors being associated with particular tastes and dietary feelings. Blue for example is an appetite suppressant, whereas pink suggests sweetness [6]. Spence et al [28] also found that even the color of a plate changes how flavors are perceived.

New ways of using ubiquitous technology to digitally enhance food and food design are beginning to appear. An example is using augmented reality to make bacon appear to have less fat through a form of visual trickery [25]. Others have attempted to stimulate our senses through audio augmentations of food. For example, Heston Blumental created the "Sounds of the Sea" dish based on how sound impacts taste perception [27]; the dish involved the diner listening to sea sounds whilst eating the meal. Visual and olfactory information can also be manipulated through the use of technology. The Meta cookie [20] combines a head-mounted display (HMD) with an olfactory display to present different kinds of cookies (e.g., strawberry, chocolate, tea). These effects make the user perceive that they are eating different flavors, but in fact they are just plain cookies.

While such digital enhancements have typically targeted adults, a number of researchers have also begun to focus on using technology to encourage more healthy eating behavior in children [29, 18]. For example, The Playful Tray [18] is a device developed specifically to address issues of poor eating behavior in young children. The project focused on game play in its design. Weight sensors placed in the tray detected eating actions, which in turn were tied to playful events in a game. A study of the system suggested it improved meal completion time.

Drawing on these works, we argue that technology interventions need to be situated within the broader practices and social etiquette of the family mealtime if they are to be effective and sustainable. Our approach is to use digital augmentation and positive feedback in the context of family mealtimes, with a focus on how it is appropriated within the context of existing parent-child dynamics. To this end, we carried out a feasibility study to explore the potential of different types of technology augmentation to motivate children to eat food they have a particular dislike of – whether we could facilitate observable behavioral improvements, by changing food presentation to make it more appealing and to encourage them with appropriate responses to their changed behavior in the setting of the family meal, where parents and siblings are present.

RESEARCH AIMS

The aim of our research was to encourage pre and primary school children to make healthier choices through digitally enhancing the food they dislike. We wanted to explore a design space of potential technologies and thus chose to look at a broad age range of children. The objective was to investigate how to digitally enhance food that young children dislike, through the use of persuasive technologies. Furthermore, we wanted to investigate whether a combination of changing the appearance of the food and a reward incentive would be able to nudge young children towards better eating behavior. Specifically, we targeted fruit and vegetables, as these are the most common problem foods amongst children. Our initial experiments were to examine the effects of digital augmentation and virtual rewards by overlaying different ambient colors on a plate in order to change the appearance of the food, and awarding virtual badges for food completion to see how it changed the children's perception and acceptance of it. The impact of this kind of technology intervention was then investigated in the context of the family mealtime.

DESIGN PROCESS

To begin, we experimented with different design ideas through a process of video sketching, prototyping and in situ evaluation. Our initial designs were based on exploring two persuasive heuristics: (i) changing the color of food on a plate and (ii) playing a game with rewards. The first was intended to change the appearance of the food to distract the child from focusing on their dislike of particular foods by seeing them in a different light. The aim of the second was to provide real-time feedback that would motivate children to try the food with the prospect of getting a reward for doing so.

(i) Changing the color of food: "disco peas"

Children are known to be attracted to a variety of bright colors [21], or foods that they can identify with sweetness [2, 3]. Our initial design exploited this. Figure 1 shows how different colors were projected onto a plate of peas making them appear more like sweets. When the peas are picked up with a spoon**,** they appear as different colored light**s** that continue to follow the moving spoon (see Fig. 1A and 1B). A sad face is displayed on the plate if it is detected that the child has hidden the peas - to discourage 'cheating' (Fig. C)

Figure 1: Coloring the peas and an unhappy face appears if the child hides the peas

(ii) Playing food games

Figure 2 shows four stages of a food game where points accumulate if the child eats the two pieces of fruit. Instructions and persuasive text are projected onto a plate. After collecting a certain number of points the child is rewarded with a small treat, such as a chocolate bar. Larger targets provide bigger rewards such as a day out to a theme park. The rationale is based on the idea that larger rewards can help provide a child with a continued impetus to eat the disliked food.

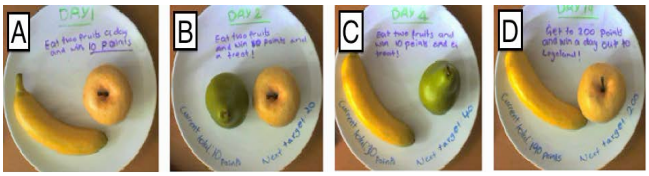

Figure 2: Screen shots of a food game

The final version of the game, shown in Figure 3, required the child to finish eating two portions of vegetables within a time limit. Instructions are again projected onto the plate indicating what to eat and the time left to do so. The persuasive text is *'Eat 3 pieces of broccoli in 10 seconds to win a badge'* (see Figure 3a). A digital badge is earned if the target portion of food is eaten within the time limit. Badges won are displayed around the top of the plate (see Figure 3b). If the child does not eat the food in the time allocated, the text says *'Better luck next time. You didn't manage to finish your broccoli on time. Try again another day to get your Broccoli Master badge!'* (see Figure 3c).

Figure 3: Eating game using augmented animations of instructions and rewards

To test the two different designs, the Wizard of Oz method [14] was used in the home of 3 families, having two children each: aged 4 and 6 (Family 1), 2 and 4 (Family 2) and 5 and 8 (Family 3). A pico projector was set up on the family dining table to project the different designs onto the child's plate. For each family, one child was given the colored food and the other the game - as it was not possible to ask each child to eat two meals in one sitting. For each design, a meal of pasta with a side of peas was used - a typical supper the family would have and the food items some of the children did not like to eat prior to the study, as reported by the parents. The degree of fussy eating varied for each child and was defined by the parents according to their lived experience of mealtimes. Informal feedback was obtained by observing what the children said during a mealtime. The children were then asked to describe what they liked/disliked about the augmented meal for the condition they were given.

All three children who were given the plate of colored peas to eat from were fascinated with the way the peas changed color. For example, the 4 year old boy from Family 1 said

he preferred pasta to peas, but it was observed that he would finish all the peas first and then push the pasta into the glowing area of the plate. He also said he wanted the colors to "*disappear once [he] ate it*". The boy also placed his hand under the projector to see the lights appear on him, exclaiming, *"now I'm glowing!"* The 5 year old in family 3 said that she preferred brighter colors and, *"want[ed] the colors to stay on the food when [she] move[d] it around"*. The 2 year old from Family 2 also spent much time carefully placing the peas individually on the different dots of light and then ate them from these. Although an elder sister in Family 2 was not taking part in this part of the study, she was very intrigued by the colors and also motivated to try some peas.

Much conversation took place during the meal with the parents encouraging their children to focus their attention on the glowing dots. One parent referred to the peas as *"disco peas"*, and hinted they were *"magic,* asking the child, *"do you think you will glow if you eat glowing food?"* Parents also suggested that the peas *"taste yummier when they are glowing."* These observations suggest that the role of the parent is central to the acceptance, persuasiveness and suggestiveness of using the persuasive heuristic of changing color augmentation.

The three children who took part in the food game were engrossed and found it enjoyable to play. The parents again played a central role; in the first instance helping them read the instructions. They also helped out by commenting on the characters appearing next to the instructions, with phrases such as *"Oh look who it is! It's Bernie the bowl!"* and *"you won't be making the characters happy if you don't eat your food"*.

It appeared that the game was able to shift the children's attention away from eating the disliked food and instead focus on aspects of the game. For example, during the meal one parent in Family 2 said to their child, *"you don't have to finish all those peas if you don't want to"*, to which she responded, *"but then I won't get the badge"* and continued eating her peas. In Family 3, the child who did not enjoy pasta, ate it all and then said, *"I hate eating pasta, but I did it because I wanted the badges"*.

DESIGNING THE WORKING SYSTEM: FOODWORKS

The evaluation of the initial designs showed that children were encouraged to try and finish foods they usually disliked through a combination of the parent's persuasion and the enticement of the digital augmentation. In doing so, there was a shift in their attention away from the food to the colored dots or the game. This enabled the children to have more fun when eating the food, rather than focus on their dislike of the particular vegetables.

Based on this finding, we developed an integrated prototype system called FoodWorks. It was designed to track and provide real-time animations in response to the children's eating behaviors. It uses a motion tracking system with simple object recognition coupled with a projector (see Figure 4) to enable the movement of specified vegetables to be tracked and followed around a plate, and different colored lights to be subsequently projected on top of them. The colored light corresponding to each vegetable switches off once it has been eaten. The system also provided virtual badges as an incentive. It rewards a child by providing certain points on completion, for example, after eating half or all the vegetables.

The detection of certain activities triggers specific changes in the animation and feedback. The system employs the image processing principles of thresholding, cropping and merging to achieve its functionality.

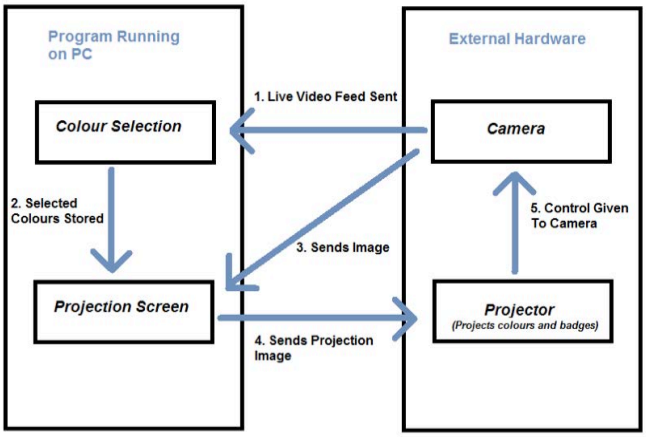

Figure 4: System architecture for FoodWorks

The hardware consisted of a Logitech HD Webcam C310 taped onto an Acer DSV0920 DLP Projector (see Figure 5). The camera lens was aligned as closely as possible to the projection lens to reduce the displacement distance between the two. The height could be adjusted according to the size of the plate and the area of the projection required.

The portable system was designed so that it could be taken into families' homes and set up on the dining/kitchen table with minimum effort and disruption by the researcher.

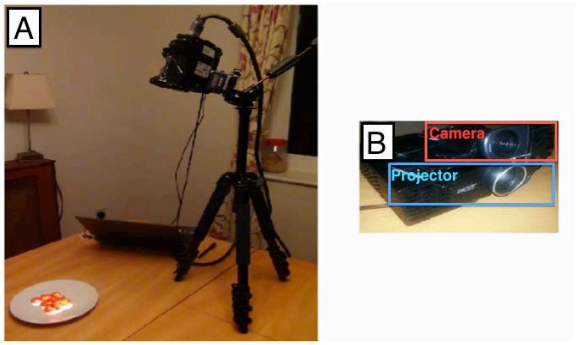

Figure 5: (A) Setup and (B) Camera attached to projector

The system works so that when the child moves the selected vegetable around the plate, the lights follow the vegetables

and change colors. The virtual badges are displayed based on the removal of the food items from the plate. This is determined by monitoring the number of pixels representing the food items being tracked. The camera scans the food on the plate. During the initial few scans, a baseline is established for the total number of pixels of each tracked color that is detected on the plate. During subsequent scans, the total number of detected pixels for each color is compared against the total in the baseline. Once half the pixels being tracked have disappeared, the half way badge appears, and once all the pixels being tracked have disappeared the full completion badge appears. Figure 6 shows the colors projected on to some carrots and half way and full completion badges being awarded.

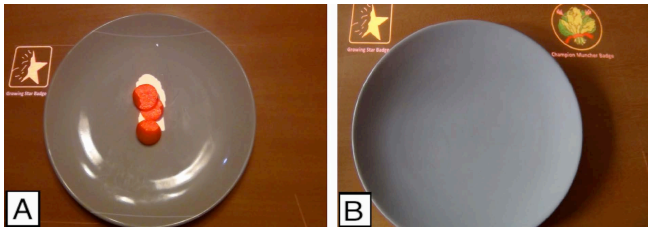

Figure 6: Virtual Badges: (A) Yellow lights on carrots and half way badge to left of plate. (B) Empty plate with full completion badge added

USER STUDY

To investigate FoodWorks within a family meal context, we conducted a user study in which the system was deployed in several homes at the family dining table during a regular meal. The focus of the user study was on the social context of how the prototype was approached, explained and understood by the children in the context of the family setting. The study was conducted as part of their typical meal patterns i.e. at home during a normal evening meal with a parent present and other family members participating as per usual.

Seven families from a variety of cultural backgrounds participated in the study. Table 1 shows details about each: all had children in the age group 3-9 years. A broad age range of children was selected to increase the potential for a wider set of concerns to be investigated and to avoid constraining the questions to be explored. Of these families, five had a child who was fussy about particular foods. In the other two families (E and F), the children participating were not considered to be fussy eaters, but were not keen on carrots and spinach/dhal, respectively. The meals prepared for the study contained at least one food item the children disliked - chosen by the parent, prior to the study, that they would not usually eat even with parental encouragement or incentives. The aim of the study was to see what children, with varying degrees of dislike, thought of and how they reacted to the digital augmentations in FoodWorks.

Family	Child (age)	Others	Fussy About	Meal Served
A	Boy (5) Girl (7)	Siblings ate together. Mother was present and cooked the meal	Both dislike carrots	Pasta, carrots and cucumbers
B	Girl (7)	Sister (10) also ate. Mother was present and cooked the meal	Indian food and beans	Pitta bread, dhal, carrots, beans and cucumbers
C	Boy (6)	Parents also ate. Mother cooked the meal	Dislikes carrots	Carrots, Salad and Sausages
D	Girl (3)	Brother (1) also ate. Mother present and cooked the meal	Doesn't eat any vegetables	Potatoes, broccoli, carrots and ham
E	Boy (5)	Brother (6) also ate. Mother, father and pet dog present. Mother cooked the meal	Dislikes carrots	Sweetcorn, beef, carrots, broccoli and garlic bread
F	Boy (8)	Boy ate alone. Mother and father present; mother cooked the meal	Dislikes spinach/dhal	Spinach, dhal, roti, salad and rice
G	Boy (5)	Sister (5) also ate. Mother present and cooked the meal	Hates cabbage	Pasta, sausage, broccoli and cabbage

Table 1: Participants, likes/dislikes and meals served

Procedure

Upon arriving at a family home, the researcher introduced herself and then set-up and configured the FoodWorks, which took about 5-10 minutes. The system was explained to the parents so they could explain it to their children. They were asked to serve up a regular evening meal that included the disliked vegetables. The children were told that they were going to be allowed to play with their food using some new technology that colored the food and gave them rewards for eating it. It was also decided not to provide instructions on the plate as in the initial design. Instead, the aim was to let the parents encourage their children in playing a game by talking them through it.

To observe the behaviors and practices during the mealtime, the researcher positioned herself at the back of the room out of the way. To complement these observations, a video camera was used to record the behavior around the meal, positioned out of the sight of the children. The children were introduced to FoodWorks and then started the meal. They did not seem to notice the camera or researcher once the meal was started and chatted as they would during the mealtime.

Data Analysis

For our analysis, we adopted a qualitative approach based on observation of behavioral phenomena complemented by a more detailed and reflective inspection of the video data.

The analysis was done by examining the moment-by-moment unfolding of action in relation to the system and the broader ecology of mealtime artefacts. These interpretations are aided by participant commentary on identified behaviors and extracting suitable quotes and conversational snippets from the videos, to illustrate particular points of interest.

FINDINGS

All the children found the animations that appeared on their plate of food to be attractive and intriguing. The combination of the colors and the rewards led them to try and, in some cases, finish the vegetables. The children who did not like carrots were persuaded to try them and, in both families A and C, finished them all. In family B, the girl who disliked Indian food and beans, also completed her meal, and in family D, the girl who never ate any vegetables was motivated to try her potatoes, broccoli and carrots. Moreover, the children in families E and F also finished the vegetables they were not keen on. In family G, the boy who had an aversion towards cabbage had a clean plate at the end of the meal.

The children started by eating the main part of the food, such as the pasta or the meat. On approaching the vegetables or food they did not particularly like, they watched the digital lights come on and off for a short period of time before trying them. Some children ate a small portion and returned to the main part of the meal, whilst others ate them in one go. After they were told, by their parents, that they would receive virtual badges for eating the colored food they focused their attention on it. The children also talked or laughed a lot when watching the lights come on and off and when they won badges.

Playing with FoodWorks

The children often played with the food that was colored by the digital animation. In family D, the young girl played with the colors being projected by moving the food around the plate whilst still eating the food (Figure 7). Playing with the colors in this way became her primary focus of attention – a distraction that allowed her to eat the meal without thinking about it. Similarly in family C, the young boy who normally had an aversion to carrots, played with them, and then ate them without any fuss. When asked why he had eaten his carrots he responded: *"I don't know, I didn't think anymore. I just ate them."*

Another common finding was the children placing their hand or arm under the projector to make themselves glow. For example, in family E, the child excitedly, exclaimed "*my hand's lighting up!*" and in family G the child put his hand or head under the projector. His mother then suggested that, "*the projector will think your head is broccoli!*"

Figure 7: Child playing with colored food

Figure 8: Child putting hand under lights

Working Around FoodWorks

The children enjoyed guessing and then seeing what color would appear next after eating a vegetable. One of the children also worked out how to get the badges to appear without eating the vegetables. In family C, the child figured out that the colors would only appear if the food was on the plate, and he would get a badge when it disappeared. Having worked this out, he moved the carrots on the plate so as to hide them from the camera's viewing area. This kind of workaround is something that children are good at but which the parents could observe and tell them not to 'cheat'.

Playing with FoodWorks to win badges was also observed in family G. Here, the boy noticed a reward badge would sometimes flicker as he and his sister blocked the view of the camera. The system mistakenly assumed that the required amount had been eaten and rewarded him a badge. As the child moved out of the camera view, the camera was once again able to recognize the presence of the cabbage still, and made the badge disappear. Having observed this system 'error', the boy continued to move his arm back and forth but also at the same time eating the cabbage - to see if the badge would re-appear and to make it remain on the plate. Once the required amount has been eaten, he was excited that the badge did not flicker any more, eagerly shouting, "*It's staying there*".

Anticipation

The children's anticipation about how FoodWorks would respond to their actions also played a role in encouraging them to eat their disliked foods. An example was at the mealtime of family G, when the sister urged her brother to "*eat that bit*" because she was excited to see what would happen if he did. When a badge was revealed she asked her

mother, "*what does it say?"* Such inquisitiveness suggests that wanting to know what had been hidden on the plate can be motivating to continue eating the food.

Social Interactions

A central part of our design was for FoodWorks to become integrated into the family mealtime. In particular, we wanted to enable other members of the family to encourage the fussy eater to eat their disliked food. The findings from the user study showed much conversation took place around the meal. Parents and siblings, together with the children, reacted and talked about the child's achievement at finishing a meal. When awarded a badge, the children announced this excitedly and proudly to their parents. In this regard, there is an important sense of parental approval at play here, the children using the attainment of the badges as an opportunity to seek praise. The system also provides the parents with a resource for giving their approval, too. These social aspects of the motivations are an important feature of the ways that the children's eating behavior is encouraged in positive ways. It is this that we now turn our attention to.

FoodWorks as a Resource for Parents

As discussed earlier, much of the organization of action around encouraging eating happens in the interaction between the child and the rest of the family – in particular, the parents. What was clear in our observations is that FoodWorks was being invoked as much by the parents as a resource as it was by the children, themselves. That is, the parents were actively using FoodWorks with the children in their attempts to encourage them to overcome the problematic aspects of their eating. There were a number of different ways that they were doing this. Firstly, the system was simply used as a means to bring back the child's attention to the plate. For example, the boy in family F was distracted during his meal and had stopped eating. The boy's parent brought his attention back to the plate by asking, "*What colors do you see?*" This then formed the initial part of the sequence of getting him to resume the pace of his eating.

The system was also used to evoke some curiosity in the child by trying to get him interested in how it might respond if he did something. In one episode, the young boy had eaten all the sausages on his plate but had left the carrots untouched. Noticing this, his father said to him "*What happens if you eat the carrots*?" At this point the boy picked up a carrot and put it in his mouth and then leant over to see what animation appeared on the plate. What is of note about this incident is that the father explicitly draws attention to the eating of the particular food, itself. The system enabled him to achieve this joint action in a way that encouraged the boy to find out more through eating.

Similar observations were found in the following vignette during the mealtime with family G. Here, the boy was not eating his cabbage and so the mother entered into a sequence of successfully encouraging him to eat it:

Mother: Go on, try some cabbage because then we can see what it does. We can see if it gives you a badge.
Child: What does that mean?
Mother: Well we need to see it. It will show up on your plate. That means you'll be a super duper eater, who tries new things... and then we can tell your friend tomorrow that you had cabbage and it made a badge on your plate. Come on, prod a bit of cabbage and put it in your mouth.
Child: Yucky!
Mother: Oh come on, I want to see what happens when you've got a clean plate.
Child: [Pauses for a while.] I'll have a tiny bit.
Mother: Oh look you've got a badge! Did you see that? [Badge appears and disappears]
Child: What where?!
Mother: Pick up another tiny piece
Child: All right!
Sibling: Put it in your mouth!
Mother: Look!
Child: [looks at the badge on the plate and gets excited] Yay!!

Here, the mother uses a subtle technique of saying that she wants to see what happens, and not just setting it up as something motivational for his own interests. That is, she is using the system to ask the child to do something for her. This establishes a different set of moral concerns for the child – one where he is being invited to please his mother and one with a different moral burden to respond positively. The mother also takes the opportunity to give the badge additional significance for the child by saying that it is for "*super-duper eaters who try new things*". She then uses the fact that the badge appears and disappears to instill some curiosity in the child and that if he wants to see what she saw, then, he will have to eat some more. We see how the child responds positively to this form of persuasion by eating another piece of cabbage.

The different colors and badges also led the families to create motivating games and narratives when eating. For example, in family D, the mother used the child's favorite color and said: "*Let's see how much you can eat before the purple comes back*" and "*the purple won't come back until you eat all your vegetables"*. While the use of gaming as a technique for encouragement is important here, there is also a hint of another aspect at play. Namely, there is a suggestion that the game is being personalized according to the particular orientation of the child.

In terms of creating additional narratives, we see this illustrated by the parent from family F, who referred to the colors as "*disco lights*" and tells the boy "*you can dance and eat*". Likewise, in family E the mother asked her boy "*shall we put disco lighting on your food every night*" to which he responds "*yeah*" and begins dancing. Here, then we can see how the parents adopt additional narrative layers to the system in order to help make the eating a fun activity that the child will want to engage in.

Some of the parents in the study also used the presence of lighting on the food as a more general reward for the children. Because the children enjoyed having the lights and rewards projected on their plate of food, one of the parents threatened to withdraw the lights from the food if the child's poor attitude about their vegetables continued: "*You won't get lights if you are moody about your broccoli*".

Involving Siblings

As well as the system being used as a resource by the parents to encourage eating, there were broader family dynamics at play arising out of its introduction at the family dining table. We see this in those families where an additional sibling was present at the table during the mealtime. Importantly, the system also captured the attention of the siblings even though their own particular plates were not augmented through projection.

Figure 9: Sibling formation and participation in two families

This had some positive benefits in the sense that the siblings joined in the gaming and encouragement. They wanted to see the lights and badges and so offered additional motivation and encouragement to their brothers and sisters to hurry up and eat in order to get them to generate the system responses.

There were times, though, when FoodWorks became a distraction and drew attention away from the children's eating of their own food. For example, in family G, the parent said of the sibling daughter:

"That's interesting because usually she would have finished all her meal, so was actually being distracted by doing that [pointing at her brother's augmented plate]."

Depending on where they were seated at the dining table, siblings would often get up from their seats in order to position themselves so as to make FoodWorks' behaviors visible to them. Certain tensions were also observed among the siblings in some households that related to the introduction of the system. For example, in family A, the sister impatiently asked her brother "*can you not eat any more pasta so I can have a go next?*" Here, there is competition to use the system among the siblings that leads to the rather counter productive request by the sister for her brother to stop eating. In this, we also see a typical source for family arguments at mealtime. Related to this, were times where the sibling showed that they felt excluded or left out when the system was projecting on the other child's plate. In family E, the child said:

"*My plate's lighting up! My plate… Dad! Dad! Daddy! Daddy! Daddy! My plate's lighting up*." The sibling then asked*: "Why haven't I got any disco food? Can't it just be on me?"*

Similarly, in family B the sibling exclaimed, "*If there were different colors on my carrots, it would put me in a good mood to eat my carrots*".

The significance of these vignettes is that while FoodWorks may have positive benefits towards mitigating issues of fussy eating, there is also some potential to introduce new problematic dynamics to mealtimes that need management by the parents. What this points to more broadly, is the need to consider the design and appropriation of using these kinds of personal digital technologies in the broader social context of the mealtime.

DISCUSSION

The aim of the digital augmentation was to persuade the children to try to eat all their vegetables by removing their focal attention from the disliked ones and to instead let them observe and play with the animated lights over the vegetables, projected from the FoodWorks set-up. Instead of seeing, for example, carrots or peas on the plate and simply refusing to eat them, the augmentation was intended to encourage the children to view the plate of food in a new way. In so doing, FoodWorks facilitated eating by shifting focus away from eating as a primary activity.

By periodically rewarding the children for eating the targeted vegetables, it also encouraged them to finish what was on the plate. What was clear from the findings was how children changed their eating behaviors and responded to eating goals in order to obtain the virtual badges. As in other domains of persuasive intervention, there is the potential that these rewards become the goal themselves; this may lead to creative, but also potentially counter-productive, ways of achieving these. Indeed, examples of such behavior included children working out that moving food out of the view of the camera was an easy way to achieve the rewards. On the face of it, such behaviors might be taken as a criticism of the system design and its limitations. One might even use this concern as a pointer to different kinds of solutions that would be less susceptible to cheating the system. Such responses, though, would appear to miss key elements of what is at play here: how these reward-related behaviors play out as a social concern rather than simply a response to the system. For example, how the children wanted to make visible their achievements to their parents was key – they wanted to please them. These dynamics become an important concern for how we understand these systems, but also where design efforts might be focused. Similarly, the creative cheating is simply something to be managed in the parent-child interaction as part of the broader socialization and moral work that takes place through the organization of the mealtime behavior.

Other aspects of the parent-child relationship were also at play here. The dynamics of these relationships are not so much determined by the characteristics of the system, but rather are enacted through them. We see, for example, subtle ways in which the parents may tailor their orientation to specific features of the system according to particular characteristics of the child and the situation. The parent may refer to specific colors or introduce a narrative that may be of particular motivational interest to their child. With the current system, while the parents were able to appropriate and contextualize what was available in the system, it was also somewhat limited in these capabilities. However, what is suggested here, is that there may be important opportunities in giving the parents additional possibilities for personalization and creativity. This could be enabled prior to the meal, but perhaps more significantly, would entail more real-time control over the system in response to the context of the child and mealtime. For example, parents could also be encouraged through customizing the system to create intrigue for the child to see what would happen if they eat their food.

Such opportunities for control are not simply a one-way dynamic. As noted in the literature, many of the social underpinnings of food aversion behaviors and success (or not) of parental strategies for dealing with them, concern the delicate plays for control and power between the parent and child. There is a balance to be had here with parents avoiding being too controlling and offering some level of responsibility to the child. In this respect, consideration should be given to how the above opportunities for tailorability and real-time control of these behaviors can be extended to the child. For example, it could be possible to engage the children in deciding on what colors, rewards or animations to use at different mealtimes. The parents could also be asked to try it for the foods they still disliked, where the children get to say what color the food (e.g. broccoli) should appear (e.g. purple or white).

What is further suggested by the study is how such interventions can create unanticipated shifts in the dynamics of the family mealtime. Here, for example, we saw how the system drew attention from siblings in both positive and negative ways. At times, the interaction was encouraging, but at others it created new forms of distraction, competition and jealousy. Of course, the specifics of these behaviors in part are bound up in some of the pragmatic characteristics of the prototype and deployment – for example, being a sole and somewhat intrusive piece of hardware. Of significance here is not so much the specifics, but more the importance of sibling dynamics as a concern in these design interventions. We need to think of this in terms of how these interventions may impact these dynamics as something to be managed. But we might also think about them as something to be exploited in more inclusive designs [cf. arguments in 22], which build positively on a sense of joint competition among siblings. This might be further extended to artifacts such as family charts comparing who had eaten their vegetables that week. These could be visualized through using a simple tablet app that could be reflected on during and at the end of the week.

Other kinds of animations could also be designed, such as suggesting which food items to eat in which sequence and the nutritional value of foods overlaid on the plate (e.g. a goodness indicator or percentage pie-chart). The important design consideration is that the animation remains playful and attractive. There is the danger that it could be seen as being too educational and then become a 'turn-off', having the opposite effect on the child.

FUTURE WORK

Sustaining Behavior Change. An important consideration is the sustained use of the system over a longer period of time to move beyond potential novelty effects. While this paper introduces an initial prototype, these effects should be explored in longer-term studies. Potential ways of doing this would be to facilitate opportunities for more creative participation by parents through tailoring it for specific family needs, e.g. timing of appearance of certain colors and enabling it to be used for different cultural eating practices. Furthermore, once over the initial hurdle of resisting certain disliked vegetables such a system may no longer be needed for the child to continue eating them.

Form Factor. The current design – a tripod on a table – is of course somewhat intrusive; however, it worked well as a prototype to enable explorations of food augmentation. In future studies, work could move towards a more complete design that can fit more appropriately into the mealtime context. This could potentially be a portable system with a pico projector and camera that could be set-up by the family, themselves. This could also enable the customization of the animation/lighting patterns by the parents.

CONCLUSIONS

Our study has explored how digital augmentation in the form of projecting changing colors and rewards onto a child's plate as they eat disliked food can be highly motivating. In particular, our system, FoodWorks, encouraged different family members, as well as the child, to take part in the child's eating practices. The playful and social interactions detracted from the focus of the child's dislike, helping them overcome their particular food aversion. Rather than pretending, or hiding the food, digital augmentation can enhance it and make it more appealing and attractive to the child to eat.

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REFERENCES

1. Bang, M., Torstensson, C., & Katzeff, C. The powerHouse: A persuasive computer game designed to raise awareness of domestic energy consumption. *Persuasive Technology* (2006), 123-132.
2. Birch LL. Dimension of preschool children's food preferences. *J. Nutr Educ,* 11 (1979), 77–80.
3. Birch LL. Preschool children's food preferences and consumption patterns. *J. Nutr Educ,* 11 (1979), 189–192.
4. Campbell, K. J., Crawford, D. A., & Hesketh, K. D. Australian parents' views on their 5–6-year-old children's food choices. *Health Promotion International,* 22 (2007), 11–18.
5. Casey, R., & Rozin, P. Changing children's food preferences. Parent opinions. *Appetite,* 12 (1989), 1–182.
6. http://www.colormatters.com/color-and-the-body/color-and-appetite-matters
7. Cooke, L. J., Chambers, L. C., Añez, E. V., & Wardle, J. Facilitating or undermining? The effect of reward on food acceptance. *Appetite,* 57 (2011), 493-497.
8. B.J. Fogg (2002) *Persuasive Technology*. Morgan Kaufmann.
9. Froehlich, J., Dillahunt, T., Klasnja, P., et al. UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits. *Proc. CHI 2009, ACM Press* (2011), 1043-1052.
10. Galloway, A. T., Fiorito, L. M., Francis, L. A., & Birch, L. L. 'Finish your soup': Counterproductive effects of pressuring children to eat on intake and affect. *Appetite,* 46 (2006), 318-323.
11. Gillis, L. Use of an interactive game to increase food acceptance–a pilot study. *Child: Care, Health and Development,* 29 (2003), 373-375.
12. IJsselsteijn, W., de Kort, Y., Midden, C., et al. Persuasive technology for human well-being: setting the scene. *Persuasive Technology* (2006), 1-5.
13. Kelder, S. H., Perry, C. L., Klepp, K. I., & Lytle, L. L. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. *American Journal of Public Health,* 84 (1994), 1121-1126.
14. Kelley, J. F. An empirical methodology for writing user-friendly natural language computer applications. *Proc. CHI 1983*, ACM Press (1983), 193-196.
15. King, P & Tester, J. The landscape of persuasive technologies. *Comm. of the ACM,* 42 (1999), 31-38.
16. Laurier, E., & Wiggins, S. Finishing the family meal. The interactional organisation of satiety. *Appetite,* 56 (2011), 53-64.
17. Lin, J J., et al. Fish'n'Steps: Encouraging physical activity with an interactive computer game. *Proc. UbiComp 2006* (2006), 261-278.
18. Lo, J. L., Lin, T. Y., Chu, H. H., et al. Playful tray: adopting Ubicomp and persuasive techniques into play-based occupational therapy for reducing poor eating behavior in young children. *Proc. UbiComp 2007* (2007), 38-55.
19. Moore, S. N., Tapper, K., & Murphy, S. Feeding strategies used by mothers of 3– 5-year-old children. *Appetite,* 49 (2007), 704–707.
20. Narumi, T., Kajinami, T., Tanikawa, T., & Hirose, M. Meta cookie. *Proc. SIGGRAPH 2010* ACM Press (2010), 143.
21. http://www.netmums.com/
22. O'Hara, K., Helmes, J., Sellen, A., et al. Food for talk: Phototalk in the context of sharing a meal. *Human–Computer Interaction,* 27 (2012), 124-150.
23. Orrell-Valente, J. K., Hill, L. G., Brechwald, W. A., et al. Just three more bites. An observational analysis of parents' socialization of children's eating at mealtime. *Appetite,* 48 (2007), 7–45.
24. Rattue, P. Vegetables And Children - Openly Showing Them Is Better Than Hiding. *Medical News Today*. 2 Mar. 2012. Web. 28 Mar. 2013.
25. Schöning, J., Rogers, Y. & Krüger, A. Digitally Enhanced Food. *IEEE Pervasive Computing*, 11 (2012).
26. Smith, A. M., Roux, S., Naidoo, N. T., et al. Food choices of tactile defensive children. *Nutrition,* 21 (2005), 14-19.
27. Spence, C. & Zampini, M. Auditory Contributions to Multisensory Product Perception. *Acustica,* 92 (2006), 1009– 1025.
28. Spence, C., Harrar, V., & Piqueras-Fiszman, B. Assessing the impact of the tableware and other contextual variables on multisensory flavour perception. *Flavour,* 1 (2012): 1-12.
29. Spermon, M., & Alonso, M. B. Getting Healthier: Creating interactive cooking tools for kids. *Proc. ICDFDFF 2012* (2012), 236-248.
30. http://www.spinbrush.com/toothtunes.html
31. Wardle, J., Cooke, L. J., Gibson, E. L., et al. Increasing children's acceptance of vegetables; a randomized trial of parent-led exposure. *Appetite,* 40 (2003), 155-162.
32. Zellner, Debra A., Siemers, E., Teran, V., et al. (2001) Neatness counts. How plating affects liking for the taste of food. *Appetite,* 57 (2001), 642-648.