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Master's Thesis

Food Media

Enhancing food experiences through technology

by

Veronica Annie HALUPKA

Submitted to the Graduate School of Media Design
in partial fulfillment of the requirements for the degree of

MASTER OF MEDIA DESIGN

at the

KEIO UNIVERSITY

June 2012

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Master of Media Design

Abstract

Our modern lifestyles are distancing us from the process of food production. Being less engaged with how our food is prepared contributes to unhealthy eating habits. This lifestyle also leaves us with less time for sharing quality face-to-face communication with our friends and loved ones. Less quality time together leads to poorer quality relationships.

In our fast evolving, highly technological world, we don't spend quality time cooking or eating together because our attention is split. Due to the wonders of modern technology, we have lost the habit of working only regular business hours. We are constantly bombarded by other demands on our time.

How can we bring people back to the dinner table together, giving each other their undivided attention? How can we find a way to bring fun back into the kitchen, engaging people with cooking?

The aim of this research is to use Media Design to re-engage people with food experiences by bringing fun into cooking and eating. Through the design and implementation of several prototypes, we have attempted to answer these questions.

This thesis explores the time line of the Kitchen and Food Media projects through four prototype systems - Flavour Visualisation, Co-Dining System, Cake Cutting and Chop Chop.

Through demonstrations, surveys and user experience analysis, we have tested our prototypes and shown that using Augmented Reality technologies in a kitchen or dining setting has no detriment over traditional tools and techniques, and enhances user experience.

Keywords: Augmented Reality, Multi-Sensory, Food, Media

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Acknowledgements

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Chapter 1

Recipe

1.1 Introduction

"Tell me what you eat and I will tell you what you are."

- Brillat-Savarin, The Physiology of Taste, 1825 [16]

This quote has transcended its original meaning and become a part of pop-culture. In this thesis we will examine Food Media, and what better place to start than with the Japanese TV show, Iron Chef[1]. A pop culture phenomenon, Iron Chef is a quintessential example of Food Media. Not a simple cooking show in the slightest, "Iron Chefs" experiment and create. They show off their skills and artistry using a special secret ingredient, and excite their diners and audience with both flair and subtlety. Food becomes not a matter of sustenance, but of pleasure and entertainment. Every episode of Iron Chef begins with this quote, as does this thesis, reminding us that eating is not only about full stomachs, but full hearts and minds too.

1.1.1 Aim

The aim of this research is to use Media Design to re-engage people with food experiences by bringing fun into cooking and eating.

1.1.2 Motivation

Our modern lifestyles are distancing us from the process of food production. Being less engaged with how our food is prepared contributes to unhealthy eating habits. This lifestyle also leaves us with less time for sharing quality face-to-face communication with our friends and loved ones. Less quality time together leads to a poorer quality of relationships.

In our fast evolving, highly technological world, we don't spend quality time cooking or eating together because our attention is split (loss of quality). Due to the wonders of modern technology, we have lost the habit of working only regular business hours. We are constantly bombarded by other demands on our time (loss of time).

Throughout my research, I sought to answer two questions:

1. How can we bring people back to the dinner table together, giving each other their undivided attention?

2. How can we find a way to bring fun back into the kitchen, engaging people with cooking?

1.1.3 The Kitchen Media and Food Media Projects

This thesis is a personal reflection of the time line of my research while at KMD. It can be seen as a narrative, with several phases of ideation, design, implementation and testing, leading to each next step.
The story of Kitchen Media and Food Media can be told through four prototype systems:

Kitchen Media: Flavour Visualisation 3.1.1
A dynamic visual feedback system allowing users in remote locations to match the taste of their dishes.

Kitchen Media: Co-Dining System 3.1.2
A remote dining system allowing users in remote locations to share a meal together. This system allows users to replicate common dining actions in remote, such as passing a dish or having a conversation. Additionally, it augments other aspects of dining by allowing users to send messages to their remote dining partner through a tablecloth display and a food printer.

Food Media: Cake Cutting 3.2.1
An Augmented Reality kitchen interface using food as the medium.

Food Media: Chop Chop 3.2.2
An Augmented Reality sound feedback system enhancing the entertainment value of an everyday cooking task.

1.1.4 Novelties

As for the Food Media project as a whole, part of the novelty of this research is in our goals. Previous Mixed and Augmented Reality kitchen prototypes were largely focussed on improving efficiency. Our Kitchen Media systems are different - we aimed to enhance communication.

From a hardware point of view, the Kitchen Media modules making up our systems were designed and engineered in-house, separately each one is a unique creation. In contrast, our next generation of Food Media prototypes uses very simple off the shelf hardware, which we have employed in a novel way.

Considering the latest Food Media prototype, Chop Chop, the novelties are twofold:

1. Motivation: Our goal with this system is purely to enhance fun and entertainment in everyday situations. Other prototypes in this area have generally sought to improve efficiency. Similar systems that also focussed on fun were implemented differently, with different results.

2. Implementation: Similar systems designed to enhance a kitchen environment have previously mostly used hardware sensing technology, whereas our system is using newer camera sensing. As for newer systems that have also used visual sensing, they have mostly been focussed on business or efficiency applications. In addition, projecting interfaces directly on food is an emerging area of research

Therefore, the crossover in our system between using new technology with the motivation of entertainment makes this research new and exciting. As this project progresses, we will incorporate more visual interface elements in addition to the sound elements already actualised, and augment further kitchen functions.

1.2 Thesis Outline

Ingredients

Chapter 2 - This chapter will examine the state of the Food Media field, and place the Kitchen and Food Media works in the context of cooking entertainment and Augmented Reality kitchen prototype systems.

Method

Chapter 3 - In this chapter, we will examine the process of conceiving and creating the four prototype systems in the scope of this project to date.

Taste Test

Chapter 4 - Testing on our prototype systems was carried out through demonstration, observation, surveys and user experience testing. This chapter examines these results and proposes several hypotheses.

Serving Suggestions

Chapter 5 - A summary of the aim, process, conclusions and findings of this project, and proposals of future works.

Chapter 2

Ingredients

To understand the context and value of this work, we shall first examine the state of the Food Media field. This is the framework upon which we have built to produce our prototypes. The Food Media landscape is diverse, and through the introduction of new technology and methods, is changing rapidly. I see Food Media as common ground between the food sciences, media and culture, a step beyond pure gastronomy into a new multi-disciplinary field. As such, we have taken inspiration from many existing media. To understand this approach, let us examine these existing media, from both a consumer and academic viewpoint.

2.1 Cooking Games

In early infancy, we learn to play with our food. You may remember your mother encouraging younger brothers or sisters to eat by saying "Here comes the airplane!" accompanied by plane sounds and actions. This kind of game is one of the first play interactions we have with our food. This is not just for fun or to calm a cranky or fussy infant. Instinctively, mothers know (or learn from their own mothers) that this is a good way to encourage healthy eating behaviours. In fact, mothers who have good play interactions with their babies are more likely to have infants with better and healthier eating habits[17].

Figure 2.1: Airfork One, Fred and Friends 2012

Many of our food associations and flavour preferences are formed in childhood. New flavours are more likely to be accepted by an infant if they are introduced along with another known and already liked flavour [26]. Children who watch either their peers or their mother consume a new food before trying it are more likely to enjoy that new food themselves[13] p.53.

Taking these factors into account, we thought about how we could create a cooking and dining scenario that would provide users with the tools to have a more enjoyable eating experience. Play can encourage good eating behaviours. Collaboration can help make unfamiliar or disliked foods more palatable.

In creating the Chop Chop prototype, we took inspiration from various existing cooking simulation games. From examining the functions of these games, we then expanded to a real kitchen environment, creating an innovative user interface and game play scenario. We wanted to take the game from simulation, to actuation. Our goal is to incorporate a fun element into every-day cooking scenarios, encouraging people to enjoy cooking more and perhaps even inspire them to cook more often. (See 4.2.1)

2.1.1 Cooking Mama

Figure 2.2: Cooking Mama, Taito 2006

Cooking Mama[4] is a game in which players perform various cooking tasks (chopping, slicing, cooking, serving) in a race against the clock. The original format of this game released in 2006 on Nintendo DS makes use of the device's touch screen as the interface. The player is presented with a choice of recipes to cook, which involve multiple steps presented in the form of mini-games. To successfully complete each task, the player must follow the instructions shown on the top screen and perform the corresponding action, e.g. drawing a straight line to slice.

"The game is a type of double signal: The game illustrates a kitchen, a person in the kitchen, a number of ingredients - that is, a fictional world. But the game also signals that this is not a kitchen. The player cannot do everything that can be done in a kitchen: Cooking Mama lets the player slice a cucumber, but only a specific type of slice."[22] p.510

This game does not require any real-life cooking skills in order to be successful. It only requires the user to learn and perform set gestures in a certain order against the clock. Can it, however, improve the player's real-life cooking skills? One could argue that perhaps some elements could be translated to a real kitchen, but there is a large disconnect, a level of abstraction.

"As Cooking Mama consists of mini-games it offers different types of interactions at different times. In framework terms, many mini-games use noun and verb metaphors (e.g. slicing with the knife and stirring with the spoon) and iconic representations (the shape of the Wiimote is similar to a spoon or a knife). However other mini-games require screen positioning of the Wiimote, as well as button presses and abstract movements (e.g. cracking an egg). In such instances metaphor analogies are weakened and representations are a combination of symbolic and iconic elements."[32] p.334 (Referring to the Nintendo Wii version of the game)

This is to say, that while many of these actions seem intuitive and native to the kitchen, some are merely representations of a task and not of performing an action. This disconnect is an area we wanted to address with our prototype. Rather than providing the user with an abstract interface, why not give them the practical means to perform that task?

To achieve this, we decided to incorporate some similar aspects of game play to Cooking Mama in our prototype, such as positive/negative feedback to provide the player with a sense of achievement. We also wanted to provide clear instructions and demonstrations of each step, in order to set the player up for success, but also to build a real-life skills platform upon which the player could expand. In this sense, we are picking up where Cooking Mama left off. By allowing for flexibility and removing abstraction, we can provide the player with a real-life real kitchen scenario in which to have fun and hone their cooking skills.

2.1.2 Cake Mania, Diner Dash

Figure 2.3: Cake Mania, Sandlot 2006, Digital Chocolate 2011

Figure 2.4: Diner Dash, gameLab 2003, PlayFirst 2005

Cake Mania[6] and Diner Dash[3] are variations on the same theme. In both games, the player races the clock to serve customers and score points. Looking at these games in terms of what is useful for our prototype, we can see that they don't really have much relation to cooking at all. In fact, they go one level of abstraction further. While we can assume the act of cooking takes place, it is not accessible to the user[22**?**] p.511. However, there are aspects of the game play, such as scoring, achievements and timing that can be used in a real-life cooking scenario.

2.1.3 Domino's Pizza Hero

Figure 2.5: Pizza Hero, Domino's 2012

A much more recent game, this was designed as a promotional and hiring tool for the Domino's Pizza company[10]. In effect it provides a pre-training scenario for employees. Players use gestures to perform cooking actions such as rolling dough and spreading sauce and toppings, and are scored on how well they perform these tasks. A high score comes with an invitation to apply at your local store for a job!

This game incorporates some similar elements to our first Cake Cutting prototype (See 3.2.1). The user has to follow directions to cut the pizza into equal slices, in much the same way as we designed our first prototype to guide the user on slicing evenly. Our prototype, however, included additional information and feedback to the user, such as calorie content and the ability to cut uneven numbers of slices.

For our second prototype, the Chop Chop game, we expanded on these aspects of game play and kitchen tasks but brought them to the real kitchen. Again, we are removing abstraction and providing the user with a direct cooking interface.

2.2 AR Kitchen Interfaces

The kitchen is considered in many cultures to be the heart of the home. It is not just a place for food preparation, but for collaboration and innovation. Even at the most basic level, helping a loved one to wash the dishes, or creating a meal out of ingredients on hand, our day-to-day activities take on new meaning when examined in the context of interaction and communication. It can be argued that we are becoming far more distant from the process of production than our ancestors. However, in the kitchen there is a return in recent years to a more do-it-yourself aesthetic, with activities such as personal agriculture becoming more widespread once again.

The kitchen is home to many native tools and gadgets. As technology advances, we are seeing more crossover between the kitchen and computing, entertainment, communication technologies, social media and even the sciences such as chemistry and microbiology. Remember the flying cars we were all promised in the future? I want to remind you of another example - the internet fridge. The internet fridge, by LG, in its various iterations, was designed as a home communications hub and logistics hub. It has not, however, become a commercial success. Hjelm describes this kind of invisible computing as the Radio Piano of our generation, referring to the time when radios were hidden inside other devices so as to make them less obtrusive and more integrated in the home[21] p.72. The fridge approximates the user's buying actions by re-ordering foods as they are used. However there is an assumption that the user does, however, want to continue buying in this pattern. It is not such a dynamic experience as actually shopping[24] p.47,48. The kitchen of the future promised to make our cooking experience more streamlined, automatic and hands-off. But it seems this is not the way most people want to enjoy their food experience. The simple act of shopping for ingredients and cooking can bring as much pleasure as eating, perhaps more so.

2.2.1 Multi-sensory effects on taste

While augmented reality (AR) is part of the reality spectrum, a kind of added layer outside our natural perception, we should consider that we actually augment the reality of food through many other means than just technological. At the most basic level, a garnish on a dish to enhance its visual appeal, or the steam rising from a pot carrying the aroma throughout the house and signalling the coming of a delicious meal, are both kinds of augmentation.

We do not taste purely with our taste buds, or even just with our mouths. We experience flavour with our eyes, ears, fingers and noses too. Taste, while a single sense, is only a partial component of flavour, which in turn, is only a single facet of a multi-sensory experience. "'Taste' refers to five specific qualities: salt, sweet, sour, bitter and umami... 'Flavour', on the other hand, involves not just those five tastes but thousands of aromas that are detected not on the tongue but in the nose... Flavour is, in fact, a composite sensation created by our brain from all our senses"[14] p.463.

By combining multiple sensory inputs, we can enhance flavours and create far more intense or pleasurable food experiences. This superadditve effect can be experienced when you salivate at the sight of a ripe red strawberry before eating it, crunch into a crisp potato chip or smell a ripe cheese. "... our brains can sometimes combine individual sensory impressions in a superadditive manner, thus giving rise to multi-sensory experiences that are far more intense than the simple combination of their individual parts would predict."[27] p.484

We can also use this effect, however, to trick the brain. In a study conducted by the University of Bordeaux, a panel of 54 tasters was given a white wine coloured red with an odourless dye. They all then described the wine using terminology associated with red wine. "Because of the visual information, the tasters discounted the olfactory information"[25], and therefore experienced the taste of the white wine as they would red. This trick of the brain can be explained physically, but goes to show just how ingrained our expectations are when it comes to consuming foods and drinks. We involuntarily experience taste in the light of our past experiences.

2.2.2 AR Kitchen Prototypes

The full time line of our Food Media prototypes can be seen in the next chapter, but for now, let us look at some existing examples of AR Kitchen Interfaces to put our work in context.

There are any number of "Smart Kitchen" Prototypes from the past few years, however the technology available for sensing has changed dramatically over perhaps only the last 12 months. With the advent of Microsoft Kinect for Windows, open API's for iPhone, Android, Kinect, and user communities developing open-source code, we can develop systems that may have seemed fanciful a short time ago.

When designing, developing and testing our first Co-Dining, Co-Cooking and subsequent Food Media prototypes, we took into account previous research on incorporating AR in a kitchen environment. Here let's examine some of these previous systems.

Counter Intelligence, MIT

Figure 2.6: Counter Intelligence, MIT 2005

The Counter Intelligence system[15] is a regular kitchen interface, augmented through the projection of information onto various appliances and surfaces. This system is designed to direct the user's attention to various elements and tasks in the kitchen to help manage multiple tasks and increase user confidence.

This system proposed an elegant solution to traditional paper-based recipes. The user follows various projected or lighted cues to know what to do next. In testing, however, the users performed no faster than the control group for the majority of tasks. At best, it can be said that this system is *no worse* than a traditional kitchen and recipe. Some elements, however, were individually shown to be more efficient, such as the illuminated drawers showing where to find a utensil or ingredient.

It should be noted that this system served a different aim, function and purpose than our prototypes, but we can still take away some valuable insights. The Co-Dining system (See 3.1.2) we developed was designed to enhance communication and create novel and interesting dining experiences. Our latest Food Media prototype, Chop Chop, is intended as an entertainment, teaching and safety tool. It is not as an efficiency aid, it is more an experience enhancement for traditional tools and methods. What we can learn from the Counter Intelligence system is that users are willing to engage with augmented interfaces, and find them no more difficult to use (if well designed) than a traditional kitchen.

Smart Kitchen, Kyoto University

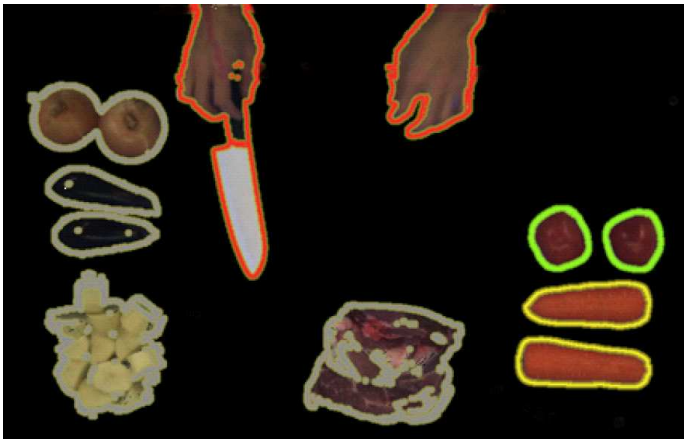

Figure 2.7: Smart Kitchen, Kyoto University 2008

Smart Kitchen[20] is an intelligent cookbook and augmented interface in one. This system uses sensing technology (optical and thermal cameras) to identify and track ingredients as the user follows recipe steps, ordering tasks according to the user's pace. This presents a challenge, as each foodstuff changes state as it is prepared. This system can recognise these changes, such as a whole carrot to a chopped carrot.

The relevance of this system to our latest prototype, Chop Chop, is in the sensing technology in common with our proposed design. Camera sensing technology has advanced since 2008, we now have cheap, easily available consumer level tools available to perform this task, such as Microsoft Kinect[5]. Using the Kinect API[11] and community developed open source software packages, we can now dynamically sense the location of a knife, hand or ingredient. We propose to use this technology to take the Smart Kitchen idea in a different direction - as a tool to provide entertainment and fun to the user through a kitchen-based game.

Smart Kitchen, National Taiwan University

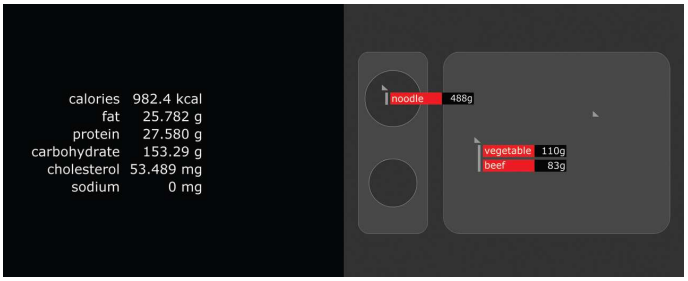

Figure 2.8: Smart Kitchen display, National Taiwan University 2010

Figure 2.9: Smart Kitchen nutritional tracker system, National Taiwan University 2010

This Smart Kitchen system[18] was created to facilitate nutrition aware cooking. This system consists of a nutritional tracker and a counter top display. The nutritional tracker uses weight and camera sensing to estimate the change in nutritional value of a meal as ingredients are added over time. The user identifies the ingredient to be added verbally, which is then matched against a database to ascertain its nutritional value. This information is then provided to the user via the counter top display.

The second version of our Cake Cutting prototype (See 4.1.3) also includes a nutrition feedback system, allowing the user to have similar control over portion size, and make informed decisions about what to eat. Our system uses a simpler approach, whereby the value of the whole dish is input by the user, and the calorie count is a factor of the number of portions. In the future we hope to extend to a similar database technique to this Smart Kitchen system, but maintain the novelty of our design, which is the projection of the information and interface directly on the food itself.

Jingle Kitchen and Table, Ochanomizu University

Figure 2.10: Jingle Kitchen and Table, Ochanomizu University 2007

The Jingle Kitchen and Table prototype system[28] incorporates sensors and switches in various kitchen tools, with the goal of creating a fun kitchen environment. The aim is to engage other family members with cooking, especially to encourage children to take an interest in healthy eating by being involved in the cooking process.

Comparing to our Chop Chop prototype, this system shares a similar motivation - to engage people with cooking through fun and enjoyment. They also enhanced a chopping board, but using a hardware sensor. Where our systems diverge is in the implementation. Since 2007 when Jingle Kitchen was designed, sensing technology has changed considerably. Our cutting system uses no special sensors and only off-the-shelf hardware.

In common with this system, we hope to augment other kitchen functions in the future, such as washing up, but using current technology and linking to social media to make a more collaborative or competitive experience.

Chapter 3

Method

The Food Media research project is an evolution of a previous project, Kitchen Media. Let us explore the progression from one prototype to the next through a time line of research, from the genesis of the Kitchen Media concept through to the current Food Media project.

3.1 Kitchen Media

As our world becomes increasingly globalised, the idea of office hours, set meal times and the family dinner have begun to disappear in favour of telecommuting and eating on the run. New communication technologies such as emails to our mobile phones, constant access to social networking, and Skype in place of face-to-face meetings allow us to stay globally connected with workmates, friends and loved ones. This presents a new communication challenge. Once considered an everyday activity, dining with others is no longer routine. The valuable communication we grew up with around the dinner table, "How was school today?" is now sadly sometimes replaced by text message. We have created a kind of false efficiency, where by making ourselves constantly available, we split our attention. How many times have you shared dinner with a loved one recently to be interrupted by an important email? Groups of teens sit down to lunch together and instead of talking, use Facebook on their phones. The art of sharing quality time together over a meal is disappearing.

We are also dealing with a technological generation gap. Older generations often feel isolated from this new technology, and so are unable to participate in the new communication paradigm we have created. This leads to grandparents and even parents being left out of the loop. Activities that were traditionally shared between generations, such as cooking and eating together, need to be maintained to preserve our quality of communication and family bonding.

The Keio-NUS CUTE Center team worked together to create several technological solutions to this problem largely created by technology. Through the design and implementation of Co-Cooking and Co-Dining systems, we aimed to bring families closer together and enhance empathy, hospitality and communication.

3.1.1 Co-Cooking

The idea of Co-Cooking came from the way many of us first learn to cook. You may remember standing at your Grandmother's hip, watching her mix a cake. The best part was licking the bowl after the cake went in the oven, the reward for working together. This kind of experience, and in fact these early childhood memories, cannot be replaced by a cookbook or a ready-bought cake.

We wanted to find a way to bring the essence of this experience back, even for users in remote locations. Say you want to cook your favourite dish, a recipe of your mother's. Wouldn't it be better if you could follow her instructions step-by-step in real time, if you could see how she is cooking and learn to match her taste?

Flavour Visualisation

We decided to focus first on one aspect of this Co-Cooking scenario, taste matching. In order to achieve the same taste as your partner's dish, we needed to develop some kind of feedback method about the taste. While taste is subjective and varies from person to person, by matching specific parameters we can at least create a chemically similar dish to be experienced by both diners.

At the beginning of our ideation process, we considered many ways to measure the taste of the dish using hardware-based methods. Measuring temperature, pH, conductivity, etc. may give us some information about the end taste, but measuring elements such as balance of sweet to salty, aroma, etc. are technologically difficult, and not so easy at this stage to incorporate in a home kitchen environment. Considering these challenges, we decided to focus instead on providing visual feedback to the user as a first step, then to perfect the sensing technology next. We chose a visual feedback system because in a kitchen environment it would allow hands-free use and could be implemented as part of a larger screen or projector based system at a later stage.

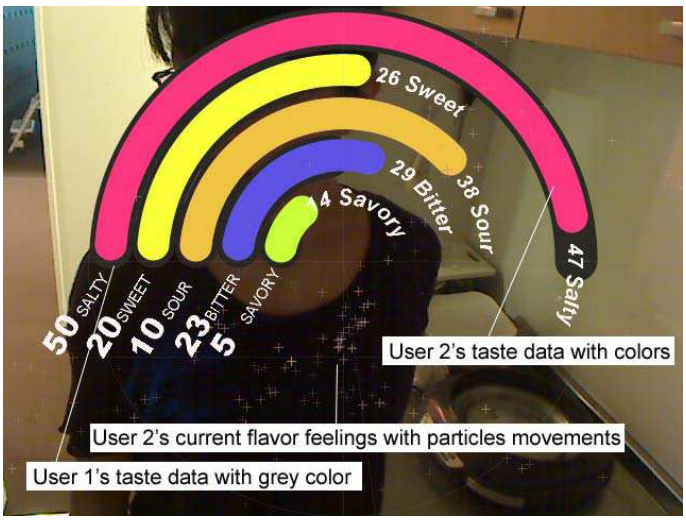

Figure 3.1: Flavour Visualisation system

Using Processing[2] an open source programming language, we customised public user contributed software to write the code for our first prototype. We considered several formats for presenting data to users visually; a scatter/cluster approach, line graphs, venn bubbles, etc. In the end, we decided on a coloured arc system. There were two reasons for this choice, one is that by making adjacent arcs it is easy for the user to compare the level of different tastes, secondly, by using colours to represent the different tastes we could contribute to the user's feeling and impression about the taste of the dish. This correlation between colour and flavour perception has been well researched and found to be strongly linked to emotion CITE. There are five basic tastes (sweet, sour, salty, bitter, umami) so we chose to represent all of them visually in our system paired with the appropriate colours.

Using hypothetical data, we tested the system and were able to adjust the visual feedback dynamically. We hope that in conjunction with sensing technology, this visual feedback could help users in remote locations to create the same tasting dish.

3.1.2 Co-Dining

In conjunction with the Co-Cooking prototypes, we started development on a Co-Dining scenario. Sharing meals is a basic human behaviour, rooted in our evolution CITE. The family dinner around the dinner table, a dinner date with a new potential partner, a business lunch and a celebratory wedding feast all share the same basic premise - that sharing food enhances communication, and eating with company increases the enjoyment of food. A nice reciprocal situation. But too often in today's globalised world, we miss out on the opportunity to share meals with others of our choosing. We decided to explore solutions to this problem from an engineering and design perspective.

Co-Dining System

When we started our ideation process for the Co-Dining system, we first considered a dining scenario. We wanted to make a system that would allow users in separate locations to share a meal together. We broke down a shared dining scenario into various actions, such as serving a dish, saying "cheers", having a face-to-face conversation and decorating the table. From these actions, we conceived various hardware prototypes and integrated them as a system.

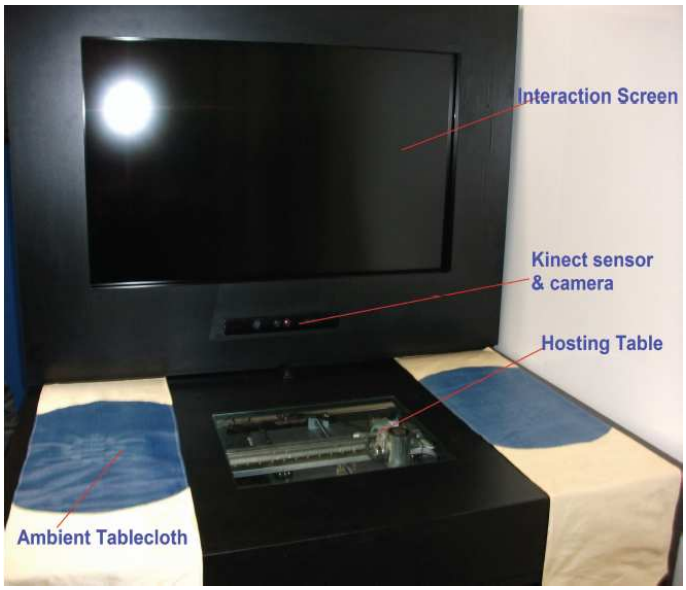

Figure 3.2: Co-Dining system table

The finished system consisted of several pieces of hardware:

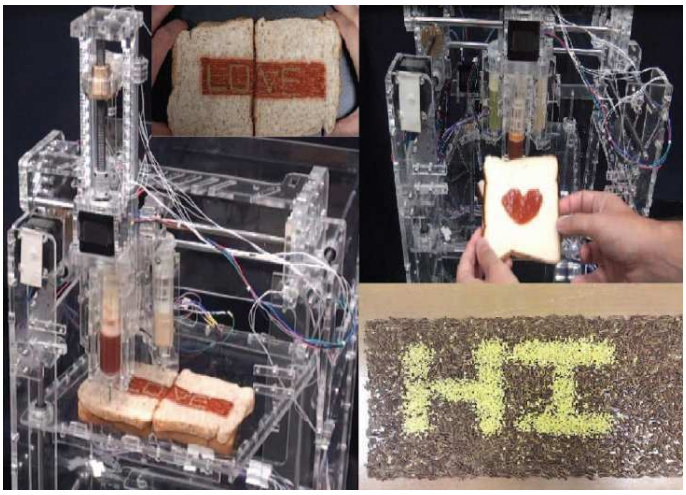

Figure 3.3: Co-Dining system Food Printer

Co-Dining Conference Screen
The screen module allows remote users to see and speak to each other, and interact in real-time. The screen also provides an interface for the system, using a Microsoft Kinect[5] to recognise gestures allowing the user to perform actions such as selecting functions, pushing buttons and drawing pictures.

Animated Tablecloth
By using the screen interface, a user can send a picture to their remote partner to be shown on a fabric display on their table. Using a thermal sensitive non-emissive fabric rapidly heated by peltier modules, the image displayed can be changed throughout the dining session.

Food Printer
Sending remote edible messages to enhance communication is achieved using a food printer. This user sends a digital message using the screen interface, such as a word or simple picture, and the Co-Dining system transmits it to the remote user by printing the message on food at the remote user's location. The "ink" used is an edible paste, such as Kaya (coconut jam). The medium used for testing was a slice of bread - a common staple.

Moving Dishes
One of the basic principles upon which we built this system was hospitality. In a shared dining situation, it is common to serve other guests at the table. We recreated this experience for a remote dining scenario using moving dishes. Each dish on the dining surface has a magnet attached. A moving magnet system was installed under the surface of the table, allowing freedom of movement in an x/y plane. The user selects a dish to serve to their partner using the screen interface. The Co-Dining system then moves the corresponding dish on the remote user's side.

Installation at NEC Research Labs in Nara

The Co-Dining system as a whole was implemented and tested at the NEC research laboratories in Nara, Japan. Over a few days, the team assembled, configured and tested the system, which we then presented to NEC researchers.

3.2 Food Media

Food Media is the next generation of the Kitchen Media project. After the completion of the installation and demonstration of the Kitchen Media prototype system at NEC, we decided to consider our direction and next steps, and entered a new ideation process.

As our previous work was largely hardware based, we decided to take a different approach. Using very simple hardware and resources available to us, we began to develop ideas more suited to a software based system. Particularly looking at the area of AR, we attempted to create new ideas that are both high impact, and technologically simple.

With this pared down approach, we started thinking about motivation. Why would a user want to use an AR kitchen system? What would they use it for? We considered and perused several approaches. First, through a long ideation process, we came up with the idea of a table-based learning system. Using education as the goal, and fun as the motivation, we designed a system to allow children to learn to eat healthier and with proper table manners. The system would also have the added goal of allowing children with disabilities to interact equally in a group dining situation.

3.2.1 Cake Cutting

In order to advance beyond the paper prototype stage, we had to prove the technology. Our first prototype was designed to test the theory and practice of using AR as a food media, before we moved on to more elaborate prototypes to meet our original objective.

With the idea of creating a kitchen tool to test our skills, we thought about common kitchen tasks that we could augment. Cutting and serving a cake brings back memories of many occasions, childhood birthday parties, weddings, celebrations. While cutting a cake in itself is easy, cutting evenly sized slices, or an odd number of slices, is not. We wanted to streamline this task, while providing the user with additional information taking a kind of value-adding approach. Compared to other hardware based systems on the market[9], ours was designed to be more flexible and to use the food as the interface, without interfering with the food itself.

Using a Microsoft Kinect[5], a small projector and a laptop computer, we customised Open Frameworks[12] libraries to perform actions such as recognising and tracking a circular object. Using a cake as the medium, we then projected

Figure 3.4: Cake Cutting system

an interface onto the cake, allowing the user to dynamically change the number of slices (and therefore slice size). We also incorporated a calorie counting option as an example of information or feedback that could be given to the user. The calorie count was in this case set arbitrarily, then modified according to the number of slices. We anticipated incorporating some kind of visual sensing module or the ability for the user to access a database to determine the number of calories in their serving. Projected uses for this system went beyond the home environment - we considered the possibility of using it in a commercial situation, perhaps to charge by the calorie, or in a health care scenario.

We carried out testing through several hands-on demonstrations, and re-designed and modified our prototype at each stage (See 4.1). However as with all good hands-on experiments, we found something unexpected! Users were engaging far more with the fun aspect of this technology, and although they appreciate that improving their cooking skills would be a good thing (See 4.1.4), they are not so motivated by it. This left us with a dilemma - go back to our original idea and approach, of creating an educational tool, or follow this new path based on the reaction of real users?

After much deliberation, we decided to follow the more interesting, and perhaps less safe path. Our original scenario included an easy to see benefit, helping children to learn a new skill. What would the benefit be to users of just having fun, or making cooking or eating more interesting?

3.2.2 Chop Chop

With the goal in mind of making a system that is based on entertainment, fun and enjoyment, we entered an ideation phase for our second prototype. Considering our successes in the last prototype - using a projected interface and customising open source code to make it work, we decided to use the same tools moving forward.

Our biggest consideration in the ideation for this next prototype was how we could incorporate other senses in our design. We wanted to continue using an Augmented Reality approach, so how could we use the tools available to us to expand on our original idea? Our first prototype primarily uses two senses - sight and touch. We can see the interface projected on the food, and we can feel when we cut the food. Secondary to this is our sense of taste and smell, which in this case was provided by the food itself.

For our second prototype, we decided to add sound as an additional sensory element. There were several reasons for this choice. One of which is ease of implementation - we could use our existing hardware. Secondly, in a kitchen environment, sound is a great way to receive hands-free feedback, wither separate to or in conjunction with visual feedback.

Our original design was a cutting game, called "Chop Chop". In this game, users are rewarded with audio feedback when they are doing a good job. Originally we conceived that there would be a visual element to this game, in the form of projected guidelines for chopping and an alarm as an added safety feature (See5.2). As we continued our design phase, however, we decided to focus primarily on the sound element. While users found our design ideas for a visual system appealing, we received far more interesting reactions from users to the sound element. We felt we had struck something novel and worth pursuing.

Having decided on the hardware and sensory elements of our design, we considered our game scenario. We wanted to give users an augmented cooking experience, something that would give them feedback on how well they are doing in the kitchen. We considered many traditional game elements, such as scoring and levelling up. In our initial prototype, however, we focussed only on audio feedback. When the user does a good job, they hear a good sound. This direct approach removed the need for a scoring system, but equally reduces the negative aspect of playing a game. The user is competing only against themselves, there is no need to compare to others or feel bad if you get a bad score. Your reward is a real life one - you get to eat the dish you have prepared.

Chop Chop System Specifications

Our Chop Chop prototype, in common with our first Cake Cutting prototype, uses very simple hardware. In the current prototype generation, we are using a laptop computer with inbuilt microphone, headphones, a cutting board and a knife. The user wears the headphones and proceeds to cut a vegetable as they usually would. The sound is picked up by the laptop's microphone, then passed through one of several customised sound filters, and played back to the user through the headphones. This has the effect of altering the sound in real time, allowing the user to experience a normal cutting scenario, but with completely different sounds. The system also incorporated a flash-based combo event - when the user hits 4 chop "beats", they are rewarded with a special sound effect.

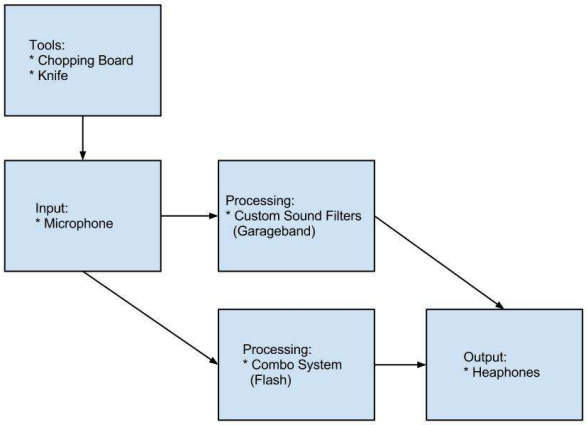

Figure 3.5: Chop Chop System Diagram

The idea itself is very simple, cute, and straightforward. But the results we achieved were far beyond what we first anticipated. Users were very engaged with the system, and expressed surprise and delight. What was a simple idea actually had a big impact. We tested the system with real users by giving them a chopping scenario: cut the cucumber, crosswise into circles. The user performed the test twice, with and without the audio feedback, and filled out a worksheet including several emotional testing criteria (See 4.2.1).

Chapter 4

Taste Test

During the design and testing phase of the current generation Food Media prototypes we conducted several demonstrations, surveys and user experience evaluations.[1]

4.1 Testing: Cake Cutting Prototype

4.1.1 Demonstration v0.1

Our first demonstration of the Cake Cutting prototype was successful in proving that the idea was interesting and engaging. Using a Microsoft Kinect[5], a Mac laptop and a monitor, we added a circular cutting guide to a real cake. Users selected their slice size, and then followed the guidelines to cut.

From this demo, we achieved several outcomes and gathered information for the re-design of our next version prototype. Anecdotally, users reported that the interface was interesting and fun, and that the cake was delicious. However, following guidelines on the monitor was challenging. We observed a disconnect between the real-life task of cutting and the virtual display guidelines. Also, the cake, Kinect and monitor had to be in alignment, otherwise the user felt a mirroring or skewing effect that made it difficult to cut.

Keeping this feedback in mind, we decided in our next version to integrate the interface and the real-life task to remove the disconnected feeling and challenges of cutting.

[1] For evaluations of previous prototypes (Flavour Visualisation, Co-Cooking and Co-Dining), see [19][30][31]

4.1.2 Demonstration v0.2.1

Our second version prototype made several improvements on the first version. The biggest change is that the cutting guidelines were projected directly on the object to be cut. In this first demonstration of the second prototype version, the position and size of the circular object to be cut (in this case, a cheesecake) was set manually. Users were far more easily able to follow the guidelines than in the first version. However, having to manually adjust the positioning was still a distraction.

4.1.3 Demonstration v0.2.2

Several improvements were made for our second demonstration, in order to streamline the interface and make it more efficient. In this demonstration the system was set up to dynamically recognise the position of the circular object (a round cheese) and a calorie slider was added, giving users the opportunity to make a more informed decision on slice size.

Anecdotal reports from users were positive. Users felt that having the interface projected directly on the food made it much easier and more intuitive to use, and that the ability to change the slice size according to calorie count was a useful feature.

4.1.4 Survey: Cooking skill and motivation

During the demonstration of the second Cake Cutting prototype, a short survey was conducted to establish attitudes on cooking (See A.1). The inspiration came from a 2011 survey by Macromill Research in Japan[7] which found that only one quarter of respondents who cooked did so because they "just like cooking".

In surveying a small, more international group of young adults, 87.5% said that they enjoyed cooking, however only 12.5% self assessed their cooking skills as "good". This suggests that cooking enjoyment has little dependency on cooking skill. In fact of the 25% who rated their cooking skill as bad, only one respondent did not enjoy cooking (For full results see A.1.2).

All but one respondent said they wanted to learn to cook better. Taking into account that we could see no correlation between skill and enjoyment, this suggests that the participants must have some other motivation.

What we took away from this short survey, is that the vast majority of respondents enjoyed cooking, and were open to improving their skills. Our next step is to discover whether improving enjoyment would improve skill, or vice versa. In designing the Chop Chop prototype, we originally leaned towards a more instructional scenario, thinking that by learning more the user would enjoy cooking more. But, as we continued our design and testing, we began to find that perhaps the opposite approach was better. This influenced our design and testing of the subsequent Chop Chop prototype.

4.2 Testing: Chop Chop

4.2.1 User experience evaluation: Cutting sounds

Methodology

Users were invited to a private room and told they would be completing a survey and a set of tasks. Only the participant and the interviewer were present. Testing was documented with photographs and notes taken by the interviewer.

The room contained a table with a chopping board and knife, and a pair of headphones connected to a laptop computer. The user was first provided with a 2 page worksheet (See A.2.1). The user answered some preliminary questions (a repeat of selected questions asked in the Cooking Skill and Motivation survey).

Figure 4.1: Chop Chop sound test - User completing worksheet

To establish the user's level of positive and negative affect, they were asked to complete a short questionnaire at three points throughout the evaluation: before, post first task, and post second task. The International Positive and Negative Affect Schedule Short Form (I-PANAS-SF)[29] method was chosen for several reasons. Compared to other methods of self-evaluation of emotion such as the Geneva emotion wheel, the I-PANAS-SF questionnaire is relatively short and simple to administer, and requires little explanation from the interviewer. It has also been established that I-PANAS-SF is cross-culturally reliable[23]. For each time that the questionnaire was repeated, the emotion criteria were randomised to avoid sequential bias.

The user was then instructed to prepare themselves to slice a cucumber. The interviewer told the user when to start cutting, and when to stop. A period of 30 seconds was timed by the interviewer, but the length of time was not disclosed to the user. The user was then directed to continue with the post-task evaluation on the worksheet, while the interviewer counted the number of slices made.

Figure 4.2: Chop Chop sound test - User chopping cucumber

The user was then asked to put on a pair of headphones, and repeat the task. The sounds of chopping were modified using one of three effects chosen at random and played back to the user in real-time. Again, the interviewer timed the user and told them when to stop cutting. The user then finished the worksheet while the interviewer again counted the number of slices made.

Results The results of the Chop Chop Sound Test were very promising, but of course not without surprises. The results are presented here as a series of statements, with accompanying statistics.[2] [3]

Chopping vegetables reduces negative affect
By employing the I-PANAS-SF questionnaire, we were able to see the changes in users' positive and negative affect over the course of the tests. Users reported lower negative affect after chopping a cucumber without sound accompaniment. However, chopping the cucumber with the sound accompaniment appeared to produce almost no further reduction in negative affect. In the odd cases where positive affect score went down from test 1 to test 2, we still saw a decrease in negative affect. Therefore, we can confidently say that chopping vegetables (with or without sound) reduces negative affect.

Chopping with sounds increases positive affect
We saw a measured increase in positive affect throughout the testing session. While users reported higher positive affect scores after chopping the cucumber without sound, they were higher again after chopping with the sound accompaniment. In particular, we can see that the median score for test 3 went through the roof after using Chop Chop. Even in the odd cases where positive affect went down or stayed the same from test 1 to test 2, we saw an increase in positive affect from test 1 to test 3 in every case. So, we can see that using Chop Chop sound effects increases positive affect more so than chopping alone. A great result!

Chopping with sounds is more fun!
Compared to chopping without sounds, users found chopping with sounds to be much more fun. This result was measured through two scales and found to be consistent. Users were asked to report after each chopping session whether chopping was not fun, OK, or fun. The score for "fun" more than doubled after the second session, compared to after the first. As a confirmation criteria, users were also asked the at the end of the test, "Which was more fun, chopping with or without sounds?" with 83% of users responding that chopping with sounds was more fun. User comments reflected this, as people reported through verbal and written comments that chopping with sounds was surprising and interesting.

[2] For full results data, please see A.2.2

[3] For clarification, the affect tests are referred to as tests 1, 2 and 3, the chopping tasks are referred to as session 1 (without sounds) and session 2 (with sounds). Please see A.2.1 for the full questionnaire.

Sound has no negative effect on chopping difficulty
There was basically no change in user reports of chopping difficulty between chopping with sound and without sound. However, verbally and in written comments, users perceived a difference in some skill areas, for example chopping speed, even though they assessed overall ease to be the same. This was reflected in the number of slices cut, with many users cutting more slices during the second session with sound than the first session without. However, this correlation could also have other causes, such as a warm up or practice period (the first chopping session) improving performance for the second, and requires further investigation.

Chopping with sounds increases hunger
Many users reported increased hunger levels after the second chopping session (with sounds). Through abduction, we could say that yes, this means chopping with sounds makes you hungrier. However, this could be attributed to many other factors, such as prolonged exposure to the smell or sight of food, and so may not be the only possible hypothesis. Users also reported little to no change in the perceived taste of the cucumber from the first session to the second session.

Chopping without sounds increases feelings of shame
One of the more interesting and difficult to explain observations from our testing was that around a quarter of users reported increased feelings of shame after the first cucumber chopping session (without sounds). In all of these cases, the users reverted to their original shame level or lower after the second chopping session (with sounds). This surprising result could have many causes and definitely requires further analysis. Suggested possible explanations are that since in all reported cases the user is male, and the interviewer is female, perhaps the users felt self conscious for social or cultural reasons, but were able to block this effect with the use of headphones in the second session, being more isolated from external factors. A lack of confidence in skills could also explain this observation, with users settling in more through practice or a warm up period for the second session.

Chapter 5

Serving Suggestions

5.1 Summary

To address the goal of creating a more entertaining, engaging and fun food experience, we developed a prototype to enhance a cooking task using Augmented Reality. The user chops a vegetable as they normally would, but hears augmented sounds, creating a novelty out of an everyday activity.

We have made several findings from the testing of the Chop Chop prototype:

1. We can make the experience of cooking more fun and enjoyable using AR technology;
2. While we have not yet proven that these systems can improve cooking skill, we see no detrimental effect - that is to say, our AR kitchen scenarios are no worse than traditional tools and methods;
3. The activity of cooking in itself improves mood, and cooking with our AR systems enhances this effect.

5.2 Next Steps

Gamification

The current Chop Chop prototype is more of a toy than a game, in that it provides entertainment and makes the experience of chopping food more fun, but it does not provide any direct challenges or incentives to the user. To make this system more game like, we propose building on the existing combo system to make the "game" more challenging and provide a sense of achievement. This could also be linked to a social networking platform to perhaps provide local scoring ladders and compete with neighbours or friends.

Mobile Format

While the current system uses very easy to obtain hardware, a smaller hardware footprint would be more useful in a kitchen environment. Therefore, we anticipate porting to a mobile application, allowing users to use a smart phone instead of a laptop computer.

Visual Interface

Visual sensing and recognition technology for foods is rapidly advancing. In a recent example, a Tokyo bakery has recently been trailing a visual-based point of sale system[8]. We have conceived and begun to design an audio visual interface and feedback system, incorporating visual features powered by a Microsoft Kinect and a projector. This would allow us in future prototypes to include features such as:

Cutting Alarm
A safety feature - A visual alarm will let the user know when they are in danger of injuring themselves by recognising the proximity of the knife to the user's other hand.

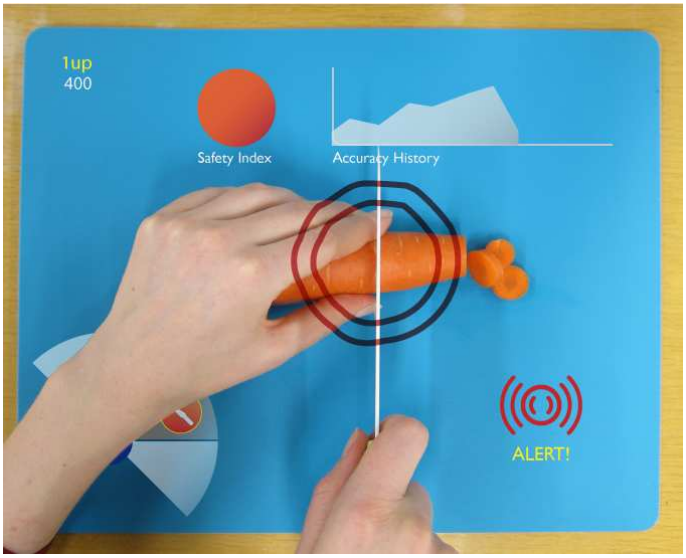

Figure 5.1: Cake Cutting future work - Food Alarm

Chopping Guides
Projected guidelines will chow the user the optimum place to cut, and could be incorporated as part of the game scenario with a scoring feature for skill or accuracy.

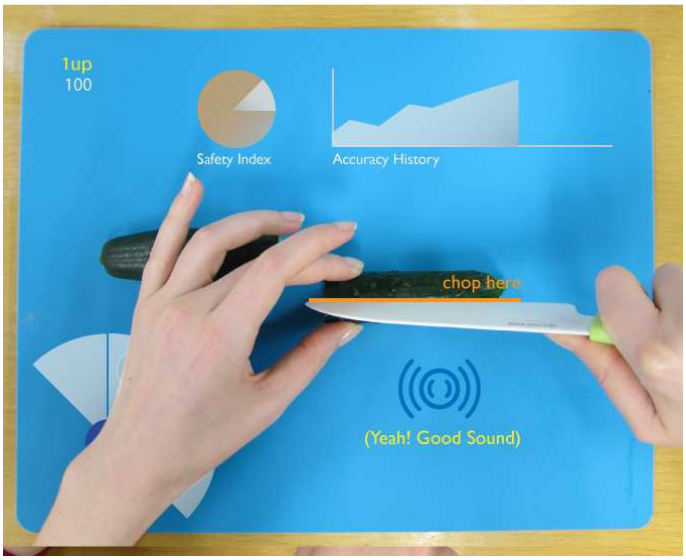

Figure 5.2: Chop Chop future work - Cutting Guide

Enhancing Other System Functions

As in the Jingle Kitchen prototype[28], we propose enhancing various other kitchen functions including cooking tasks, and other chores such as washing the dishes. As a step beyond this prototype, we are using newer camera sensing technology and anticipate connecting this system to a social networking service.

5.3 Exhibitions and Conferences

The Chop Chop system has been submitted for the demonstration and poster sections of the Advances in Computer Entertainment (ACE) conference to be held in Nepal in November 2012.

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Appendix A

Surveys, Tests and Results

A.1 Survey: Cooking Skill and Motivation

A.1.1 Survey

Age: (Please circle)
21-25 26-30 31-35 36-40 41-45 46-50 50+

Gender:
Male Female

Do you enjoy cooking?
Yes No

How would you rate your cooking skills?
Bad – Average – Good

Do you want to learn to cook better?
Yes No

What is your favourite food?

Figure A.1: Cooking Skill and Motivation survey

A.1.2 Results

Survey- Cooking Skill and Motivation

Q 1.	Age					
	21-25	26-30	31-35	36-40	41-45	46-50
n	6	6	4			
%	37.5	37.5	25			

Q 2.	Gender	
	Male	Female
n	9	7
%	56.25	43.75

Q 3.	Do you enjoy cooking?	
	Yes	No
n	14	2
%	87.5	12.5

Q 4.	How would you rate your cooking skills?		
	Bad	Average	Good
n	4	10	2
%	25	62.5	12.5

Q 5.	Do you want to learn to cook better?	
	Yes	No
n	15	1
%	93.75	6.25

Q 6.	What is your favourite food?	
	Cuisine	Specific dish
	7	9

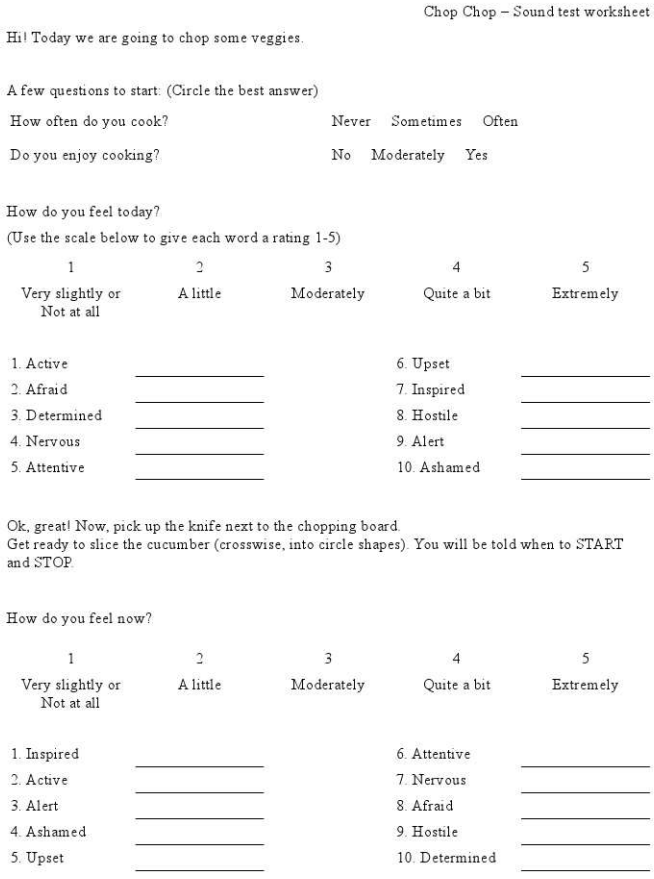
Responses:	Everything	Okonomiyaki
	Japanese Food	Dawood Basha
	Cakes	Kebab
	Italian (Pasta)	Ramen
	Thai food	Chocolate
	Pasta	Natto & Cheese
	Curry	Lasagne
		Poppy Seed Chicken Casserole
		Salmon

Page 1

Figure A.2: Cooking Skill and Motivation survey results

A.2 User Testing: Chop Chop

A.2.1 Test



Chop Chop – Sound test worksheet

Hi! Today we are going to chop some veggies.

A few questions to start: (Circle the best answer)

How often do you cook? Never Sometimes Often

Do you enjoy cooking? No Moderately Yes

How do you feel today?

(Use the scale below to give each word a rating 1-5)

1	2	3	4	5
Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely

1. Active	_____	6. Upset	_____
2. Afraid	_____	7. Inspired	_____
3. Determined	_____	8. Hostile	_____
4. Nervous	_____	9. Alert	_____
5. Attentive	_____	10. Ashamed	_____

Ok, great! Now, pick up the knife next to the chopping board.
Get ready to slice the cucumber (crosswise, into circle shapes). You will be told when to START and STOP.

How do you feel now?

1	2	3	4	5
Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely

1. Inspired	_____	6. Attentive	_____
2. Active	_____	7. Nervous	_____
3. Alert	_____	8. Afraid	_____
4. Ashamed	_____	9. Hostile	_____
5. Upset	_____	10. Determined	_____

Figure A.3: Chop Chop sound test worksheet - Page 1

Cool. A couple of questions for you:

How easy was it to chop the cucumber?	Difficult Ok Easy
How much fun was chopping the cucumber?	Not fun Ok Fun!
How long would you say you were chopping?	Minutes:_____ Seconds:_____
How hungry are you right now?	Not hungry Kind of hungry Hungry
Eat a slice of cucumber. How does it taste?	Bad Ok Good

Ok! Now put on the headphones and pick up the knife again.
Get ready to slice the cucumber (crosswise, into circle shapes). You will be told when to START and STOP.

Right! One more time...

1	2	3	4	5
Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely

1. Attentive	_____	6. Determined	_____
2. Afraid	_____	7. Active	_____
3. Hostile	_____	8. Inspired	_____
4. Ashamed	_____	9. Alert	_____
5. Upset	_____	10. Nervous	_____

Thanks! So, a few questions again:

How easy was it to chop the cucumber?	Difficult Ok Easy
How much fun was chopping the cucumber?	Not fun Ok Fun!
How long would you say you were chopping?	Minutes:_____ Seconds:_____
How hungry are you right now?	Not hungry Kind of hungry Hungry
Eat a slice of cucumber. How does it taste?	Bad Ok Good
Which was more fun, chopping with or without sounds?	Without sounds With sounds
How often would you cook if it was more entertaining or fun?	Less often Same amount More often

Thanks a bunch, if you have any comments, please write them below.

Figure A.4: Chop Chop sound test worksheet - Page 2

A.2.2 Results

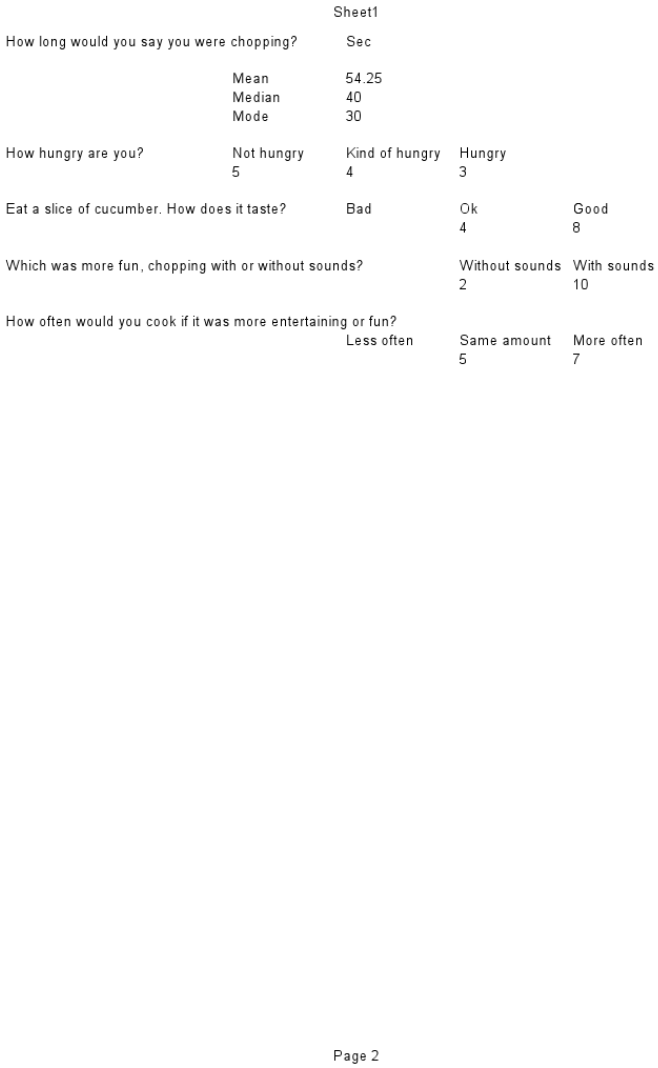
Sheet1

Chop Chop – Sound Test Results

How often do you cook?		Never	Sometimes	Often
		1	7	4
Do you enjoy cooking?		No	Moderately	Yes
		1	2	9
I-PANAS-SF	1 Positive	Negative		
Mean	13.25	7.67		
Median	13	6.5		
Mode	13	5		
I-PANAS-SF	2 Positive	Negative		
Mean	15.25	6.75		
Median	15.5	5		
Mode	14	5		
How easy was it to chop the cucumber?		Difficult	Ok	Easy
		1	3	8
How much fun was chopping the cucumber?		Not fun	Ok	Fun!
		1	6	5
How long would you say you were chopping?		Sec		
	Mean	50		
	Median	30		
	Mode	30		
How hungry are you?		Not hungry	Kind of hungry	Hungry
		6	5	1
Eat a slice of cucumber. How does it taste?		Bad	Ok	Good
			3	9
I-PANAS-SF	3 Positive	Negative		
Mean	17.75	6.42		
Median	19	5		
Mode	15	5		
How easy was it to chop the cucumber?		Difficult	Ok	Easy
		1	2	9
How much fun was chopping the cucumber?		Not fun	Ok	Fun!
			1	11

Page 1

Figure A.5: Sound Test results - Page 1



Sheet1

How long would you say you were chopping?		Sec		
	Mean	54.25		
	Median	40		
	Mode	30		
How hungry are you?	Not hungry	Kind of hungry	Hungry	
	5	4	3	
Eat a slice of cucumber. How does it taste?		Bad	Ok	Good
			4	8
Which was more fun, chopping with or without sounds?			Without sounds	With sounds
			2	10
How often would you cook if it was more entertaining or fun?				
		Less often	Same amount	More often
			5	7

Page 2

Figure A.6: Sound Test results - Page 2

Sheet2

I-PANAS-SF	1	Positive	Negative
	Mean	13.25	7.67
	Median	13	6.5
	Mode	13	5
I-PANAS-SF	2	Positive	Negative
	Mean	15.25	6.75
	Median	15.5	5
	Mode	14	5
I-PANAS-SF	3	Positive	Negative
	Mean	17.75	6.42
	Median	19	5
	Mode	15	5

Page 3

Figure A.7: Sound Test results - Page 3