Future Food:

Can emerging technologies enrich the experience of cooking and eating?

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Abstract

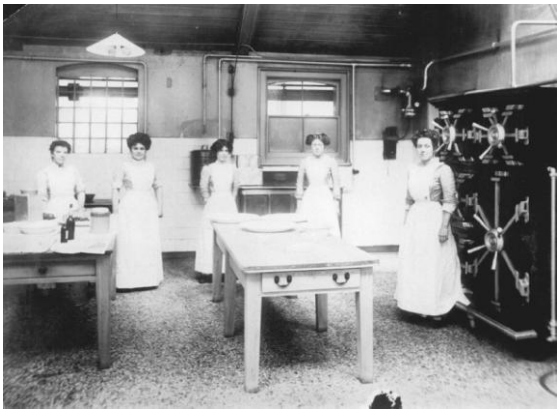
The future food project aims to improve our relationships with food, in order to better both physical health and mental wellbeing. This paper presents the outcomes of this project: the Chefmate and the Chefmate Hob. These devices harness emerging technologies to provide a greater amount of food related information for the user, in a way intended to enrich the cooking and eating experience, taking into account social as well as practical considerations.

1.1. Introduction

Cooking has made us human. To take on the nutrients we need by eating only raw unprocessed food would take 6 hours of chewing per day – the adoption of cooking caused an evolutionary shift that allowed our guts to be smaller and brains to be bigger, freeing up extra time and energy for the development of social structure.[1] Anthropologists have argued that the adoption of cooking by humans begat monogamy and gender roles and has been a defining element in the make up of contemporary cultures.[2]

Hunger is one of humanity's greatest needs and has driven key events in history. Food has acted as a catalyst of social change, political organization, geopolitical competition, industrial development, military conflict and economic expansion.[3] Napoleon's rise and fall was closely linked to his capacity to nourish his large armies. In the twentieth century, Communist leaders used food as an ideological weapon, resulting in the death by starvation of millions in the Soviet Union and China.[4] Even today; the foods we consume connect us to global debates about international relations, development, sustainability, and innovation.

Food helps to define humanity on a micro scale as well as the macro. Food brings people together, and is sometimes more a context for interactions than a means of nutrition. It is an essential part of everyday human lifestyle, regardless of culture. In an average lifetime British women spend 3 years and men 1.5 years cooking, with an additional 4.5 years and 4 years of eating respectively[5]. However something that has a huge impact on us physically and mentally and takes up so much of our lifetime is often considered a nuisance, and is dealt with in the most minimal way possible, or in a way damaging to our physical health. In 2008, one quarter of adults in the U.K were classified as obese according to statistics from the NHS.[6]



But where does design come into the equation? Over time, developing technologies have revolutionised the way we interact with food. For example, developments in appliance technology have transformed the kitchen from a smoky workroom into what many consider to be the heart of the household and an integral part of family life. In the developed world, advanced farming methods have allowed access to a better diet, which has contributed to increased life expectancy. The future advancement of genetically modified foods has the potential to greatly reduce world food shortages and improve quality of life for millions of people worldwide. Design and technology have transformed our relationship with food from a mere means of survival to one offering the potential of pleasure and socio cultural inclusiveness.

Given the importance of food to quality of life, and the fundamental role of design and technology in the contemporary context, the main question I have investigated in the project is this:

How can our relationships with food be improved, in order to better both physical health and mental wellbeing?

The aim of this report is to contextualise the outcomes of the project and to explain the design

process used. Firstly the aims and motivations of the project will be outlined; following this, a description of the different research methods used will be given, including why they were used and the results of this research, in terms of concept generation and practical specification for the devices. Subsequently the concept development process is explained, followed by a breakdown of the outcomes of the project. Finally the limitations of both the outcome and the process are discussed, with suggestions for possible further research.

1.2. Aims

The aim of The Future Food project was to create a device to help home cooks improve both the experience of cooking and the quality of the meal. The project aimed to make the cooking process more enjoyable and less stressful, aiding users of varying abilities to improve their skills, as well as providing practical information such as nutritional value. An integral part of improving the cooking experience was helping users to concentrate more on the areas of their relationship with food from which they derive the most pleasure: the sensual, emotional, creative and social. Due to the highly subjective nature of the aims, a cycle of testing and improvement was to be used to evaluate the outcomes.

1.3. Motivations

In the early stages the project concentrated on reducing energy use in the home. Much of the research was based around providing users with real time information about their energy expenditure, and how best to visualise this data in a way that would encourage users to reduce energy use. Also the role of memory was investigated, and how cues could be provided to prompt energy saving actions. Initial investigations included using an unfamiliar texture to act as a cue to help users remember to switch off lights. Research moved on to investigation of smart energy meters and energy saving social cooking. It was the idea of combining these two areas that inspired the project, with the principles of information visualisation and memory cues remaining key concepts throughout.

1.4. Context

The practical elements of cooking often become more important than the enjoyable elements, in the same way that we might sometimes choose to own a family car over a sports car. Many successful food products are popular not because they are especially delicious, but because they are practical, for example frozen pizza.

Research carried out at the University of Michigan shows that people frequently choose meals immediately before they cook them, often whilst looking in the fridge or kitchen cupboards.[7] This is especially common for professional people with busy lifestyles, and is compounded by the fact that more and more people are living alone, with no one to share cooking chores with.[8] It is most common for people to have a memorised repertoire of everyday meals, and a few special recipes for entertaining.[9] It can take too much time and effort to search for a new, more exciting recipe at the last minute, and even then all the ingredients have to be present in the user's home.

However, both eating and cooking a new recipe can be rewarding for the cook and any guests. It can provide a talking point at the dinner table, and the creative element in cooking something different can be much more rewarding to the cook than completing a monotonous task that has been performed uncountable times before. Cooking food from other areas of the world or from other cultures can be a window into places the diner has never visited. If a person is accustomed to eating unhealthy food, cooking healthier dishes could vastly improve their wellbeing over their lifetime. A change in ethics or religion can sometimes require a dramatic change in diet – technology has the potential to make this process easier.

Emerging technologies such as projection, motion tracking and pervasive computing have the potential to provide more relevant information to the user compared to traditional methods such as cookbooks or even internet recipes. This has been quantified in research such as the Augmented Reality Kitchen (ARK) project carried out at MIT: a kitchen fitted with numerous sensors and visual feedback mechanisms, designed to guide the user through every step of the cooking process. The purpose of ARK was to create an environment to quantify how useful various emerging technologies could be in the kitchen environment. The project demonstrated the practical usefulness and suggested social benefits of these technologies[10,11,12]. Until recently high cost has prevented widespread use of these systems but lowering price has introduced new opportunities for consumer products.

An existing example of where digital technology has been utilised to change the cooking process is the use of recipe websites. Cooking websites and the ability to search recipes offer a huge improvement in variety over cookbooks. Many also include basic social features which can help to add meaning to a meal. The ability to search by ingredients takes into account the fact that many people decide on a dish too cook at the last minute. However despite the benefits, internet technologies such as laptops are not kitchen proof, using them while cooking is likely to result in them breaking or getting dirty. Laptops and websites are useful for planning but cannot become as tightly integrated in the process and flow of cooking in the same way that a cookbook might. Integration into the flow of cooking has the potential to educate and assist the user more effectively – by giving relevant information at the required time. If the variety, depth of information and social possibilities of the internet could be accessed in a more kitchen friendly manner, in a way that helps users organise their ingredients in advance so they do not have to compromise, the cooking and dining experience could be improved.

Currently a small number of digital devices are available which harness the information on the internet in a kitchen context. Despite the additional flexibility they bring to the kitchen, the key weakness is that they add little more to the overall experience of cooking and eating a meal.

An example is The Demy. The Demy is a small recipe reader which syncs up to a user account on its partner website, keyingredient.com, updated through USB. It is currently the only widely available dedicated recipe reader on the market. It allows the user to search through a database of up to 2500 recipes, and provides various other useful features such as timers and unit converters.[13]

The Demy is undoubtedly a useful device, however it offers little more than the features already available on smart phones, for example the iphone combined with software such as the Cookmate app.[14] Despite the practicality that the kitchen safe element provides, retailing at around $200, it might not be seen as a good investment considering the lack of functionality compared to laptops or smart phones. Another issue is that because it must be used in conjunction with a website, it assumes a certain level of technological literacy which could deter potential users who are not confident using computers, or are not comfortable with the combination of food and digital technologies.

One way to add value to a device such as the Demy could be to look at the area from a more experiential point of view, concentrating on the emotional and social elements of cooking and eating. The practical elements are still very important, however if a device could more effectively enrich the overall experience of cooking and eating itself then the product would represent better value for money.

1.5. Brief

Having conducted initial research and chosen a more defined area of interest, a brief was written:

"The purpose of this project is to create a way for users to access information to help with planning meals from a weekly to per meal basis with a strong social networking element. It is to take the form of a device which is to be used inside the kitchen, and its use should become part of cooking. The aim of this is to help users cook a wider variety of meals, make more informed decisions about cooking, help with planning grocery shopping and ultimately improve the experience of cooking and eating."

2. Research

2.1. Outline:

The purpose of the research as a whole was to:

- *Gain a personal understanding of the issues involved*

- *Inspire design ideas*

- *Create insights into problems and areas of possible improvement*

- *Build on previous research*

- *Learn about the kitchen environment and how people interact with it*

- *Identify a potential user base*

- *Inform the technical elements of the outcome*

- *Formulate a specification for the outcome*

At an early stage in the project I planned a broad research strategy that focussed on interaction with people with a wide variety of attitudes to food. The project was ultimately about people and their emotions in relation to eating, so it was appropriate to focus the research on more human elements. This approach inspired a broad range of concepts, based on designing with individual attitudes in mind. These concepts could then be used to inform a final outcome which could appeal to a range of people. The variety of participants in the research allowed cross-cultural comparisons. This research created useful insights based on questions it rose concerning why cultural differences in attitudes, behaviour and artefacts exist. Many of the techniques were adapted from a selection of

those outlined in *"Design research: methods and perspectives"*.[15]

2.2. Literature Review

The purpose of the literature review was to:

- *Determine which areas have and have not been investigated*

- *Find insights from research in the area of food, cooking and the kitchen, as well as in areas with parallels to this project.*

- *Gather statistical data about potential users*

- *Determine if there is consensus about the issues the project deals with*

- *Identify methods used by other researchers and determine the pros and cons*

- *Identify gaps in knowledge in the subject which would be useful to address in my research*

- *Identify possible areas of further study recommended by other researchers*

- *Weigh up the pros and cons of research design outcomes (if any)*

- *Determine how soon future developments in technology/science are likely to become commercial*

- *Find data and related research to justify the design outcome*

Firstly, areas of contemporary research were investigated. This helped to establish what had already been achieved, and where there was potential for new research. Specific findings in related research studies helped to inform elements of the design outcome, and inform the direction of further research. There has been quite a large amount of academic research into the area of using smart technology in the kitchen environment to augment both the cooking and eating experience. One example of this is the Ambient Kitchen project carried out at a number of universities across the UK. This research environment was designed for testing how to aid people with dementia in completing kitchen tasks[16], however many of the findings could be used in helping a wider section of kitchen users.

Once the boundaries of the project were established (as defined by the design brief), parallel areas could be analysed in order to learn how similar design problems had been overcome. This could be used to both inspire design ideas and justify elements of the design outcome which could not be tested.

Lastly past developments in the field were investigated – how the kitchen environment has developed, how cooking instruction has changed and how design has transformed relationships with food in a broader sense. Understanding the history of food, cooking and the kitchen was helpful in understanding the reasons behind the existence of current technologies.

2.3. Related Products

There are few existing commercial products in the area of digital cooking technology in the kitchen. The Demy is discussed above. No other dedicated digital devices are available, although numerous concept designs have been published[17,18,19]. Analysis of the pros and cons of recipe websites, iphone/ipad apps and traditional cookbooks have influenced both the software and hardware design. A discussion of cookbooks and cooking websites is presented later in the report.

2.4. Ethnography

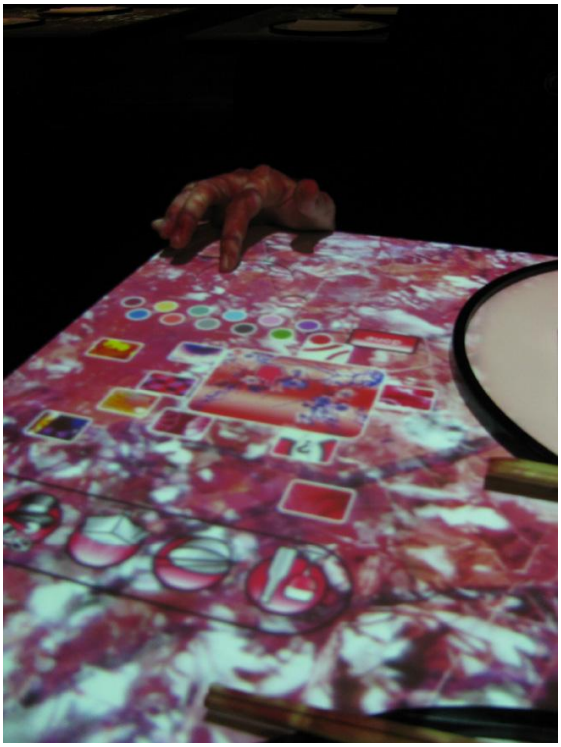
This stage of the research consisted firstly of interviews, followed by a series of small observational experiments. The ethnographic research carried out for the project was limited, due mainly to constraints on budget and time. No significant incentive was available to potential participants, so numbers and range were limited to people who could be persuaded to participate as a favour. Because of the small number and relatively narrow socio cultural range of participants, findings presented here are not intended to amount to quantitative evidence. The purpose of the ethnography was to help greater understand various emotional and practical elements of how people relate to food, and the cooking process itself by triggering ideas which could be researched further in more quantifiable methods. A combination of interviews and observational experiments were carried out. These are detailed further in appendix 1.

2.5. Experience

In this stage of the research I set out to experience first hand various elements of food and the cooking process. The purpose was to gain a greater emotional empathy with the trials and tribulations of the cooking experience, and help establish weather the use of technology really can improve our relationship with food. Obviously food and cooking were something I had encountered frequently before. In order to gain fresh insights I sought new experiences relevant to the aims of the project. The understanding gained from this section of the research was not as quantifiable as other areas, but was a great help in giving me an impression and feeling for the area as a whole. In fact this method of research greatly influenced the final outcomes, as explained below.

I felt the most effective way to empathise with the emotions of cooking something new was to be taught to cook new dishes for myself, so I took a cooking lesson. In this lesson we cooked complex meals from a recipe, with the aid of an experienced chef available if problems arose. This method was very effective, as it allowed everyone there to cook at their own pace, while learning new techniques where needed. It was this concept - having a bank of knowledge with a strong visual element that can be accessed when needed so as to not disturb the flow of cooking, that ultimately lead to the design outcomes. If cooking from a traditional recipe, I feel my result would have been significantly worse, or would have taken much longer to complete. Watching the chef carryout an example task was much more useful and quicker than reading the same process described in text. Additionally, because the lesson was carried out in a group, the social interactions and conversation sparked by food and cooking helped to stress the importance of the social element of the cooking process.

Having taken the cooking lesson I wanted to further explore the potential benefits of technology to learning. Many museums have adopted new technologies to make learning a more pleasurable process, and help otherwise perhaps uninteresting topics become more accessible, especially to children. The Natural History Museum's newest permanent exhibit, the Darwin Centre, is an excellent example of this making extensive use of touch screen technology, projection and barcode scanning.[20]



Having explored the relationship between technology and learning I wanted to explore the relationship between technology and food. I visited a restaurant called Inamo, where an interactive menu is projected onto your table. All ordering is done through an interactive interface projected onto the table, which offers additional features such as games, local nightclub information and chefcam: a camera in the kitchen so diners can watch their meal being cooked.[21]

3.0. Research Findings

3.1. Problems with food and cooking

This section of the report explains the problems the research found people had with food and cooking. These include uncertainty, distraction, inexperience, inefficiency and a lack of nutritional knowledge.

3.1.1. Uncertainty

This is not knowing what to cook, or not knowing how to cook a given meal. The time a meal takes is also a factor, as is expense. From

the interviews, ethnography and literature review, possible causes of uncertainty were found to be:

- *Poorly stocked kitchen*

- *Lack of cooking knowledge/experience*

- *Guests have specific dietary requirements and an unfamiliar style of cooking is needed*

- *Want too cooks something that someone else will like*

- *Want to try something new but don't know what to do*

- *Deciding what to cook for a dinner party*

- *Balancing the needs of everyone in a family meal*

These are explained in further detail in appendix 2.

Many of these issues singularly are solvable with existing solutions; however it is common for many of these problems to occur at the same time. Juggling all of these factors can make choosing a meal very difficult. Problems with existing methods mean that they are often not used as solutions and the user will revert back to cooking meals they are comfortable with.

Choosing a recipe online can be difficult because of the vast number of unverifiable recipes available[22], and the anonymous nature of these recipes ignores the social element of cooking. It also requires a certain level of computer literacy, and presumes that people like using computers in the first place.

3.1.2. Distraction

When cooking it is common for an outside influence to distract from the process, for example a telephone call or a cook's child needing help. As well as being side tracked by outside influences, the user can be distracted or confused when trying to multi-task if cooking many dishes at once. This was seen a number of times during the observational experiments, in one case leading to problems and stress during cooking after receiving an important telephone call. Being pre-occupied with personal issues can also distract from the cooking process, contributing to the short term memory becoming overloaded[23]. Even without external distraction, the observational experiments found it is common for a cook to forget to do something in preparing the meal: minor mistakes such as leaving out a non-essential ingredient were common.

Cooking a new recipe has the potential to present all these complications plus more to the multitasking process, and is therefore an area ripe for distraction. Loukopoulos writes about carrying out a new action in the *Human Factors Journal*:

"When an individual tries multitasking in a situation that involves novel tasks, complex decision making, monitoring or overriding habits, it all falls apart" (Loukopoulos 09)[24]

How does the brain handle distraction? We tend to think of multi tasking as doing or thinking about a number of things at the same time, however this is generally not how the brain actually works. In most circumstances the brain can focus on one task at a time only, and the ability to prioritise and switch between tasks effectively defines good multitasking. Multitasking can be completed in different ways: steps of one task can be interwoven with steps of others, tasks can be completed sequentially, or tasks can be ignored if they are deemed unimportant. As well as adding extra loading to working memory, all of these remove the natural sequence of cues that a person is in the habit of reacting to.[25]

Fighter pilots are an extreme example where multitasking is needed, often in environments of reduced oxygen with many possible distractions, such as approaching missiles or extreme G-forces. To cope with this, fighter pilots must pass a multitasking test, and complete rigorous training including:

1. *Habitualizing routines* – using mnemonics, pilots must memorise the cockpit layout and systems.

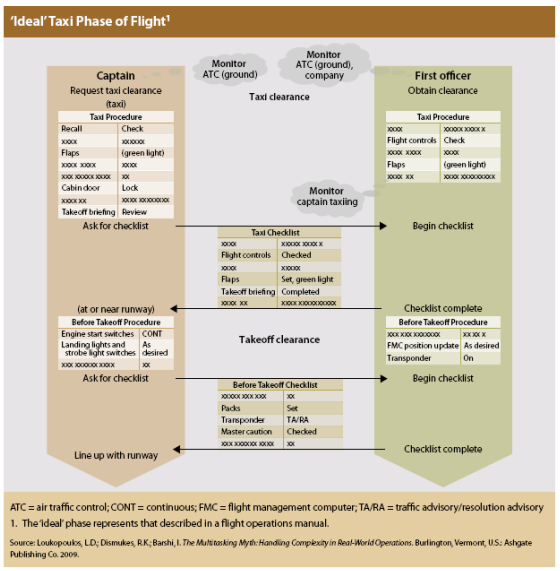
2. *Know your limits* – Pilots complete tasks in centrifuges and under hypoxia to teach them to recognise and operate within their own limits

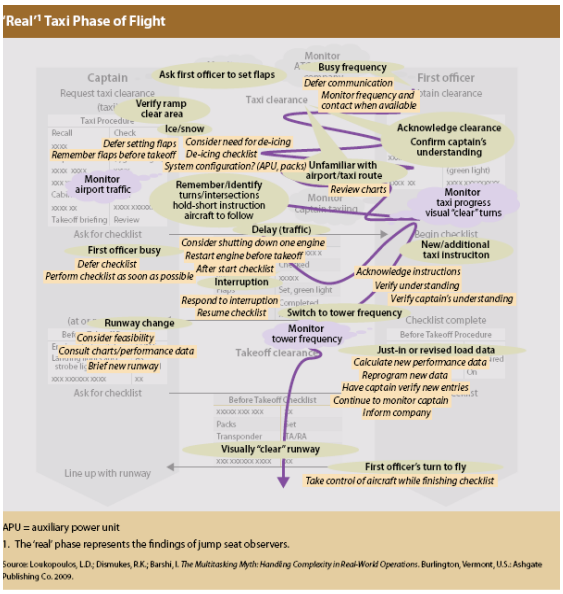
3. *Hone attentional flexibility* - Pilots learn tasks and then practice switching between them

4. *Debriefing* – identifying anything that went wrong and trying to make sure it doesn't happen again [26]

Similar processes are carried out naturally in the kitchen environment, and are essential elements of becoming a good cook. The more a user cooks, the more they become familiar with the layout of the kitchen and their capacity to multitask. But unlike a cockpit, the kitchen is a transient environment, with the uncertainty of new ingredients or misplaced utensils. Encouraging and aiding better kitchen organisation could help reduce distractions such as these; this is discussed further in the 'Efficiency and Flow' section of this report. If a cook knows their limits, they are less likely to end up making mistakes. However unlike a fighter pilot the common home cook is unlikely to want to take time out to complete intensive training, so any teaching should be carried out during the cooking process.

With this said, even intensive training cannot sufficiently reduce human error to make flying aircraft such as a fighter jet or commercial airliner safe without the aid of additional technology. For the purposes of this project it is useful to look at how pilot error in the cockpit is compensated for by technology and flight procedure. One possible future solution being developed by NASA is to use neural imaging to detect when pilots' brains are too overloaded and compensate by providing only essential information during this time[27]. Comparable research projects have used analysis of human eye movement to detect intent in the kitchen[28]. Such complex sensing is out of the scope of this project, but could prove useful for helping to display relevant information when needed if the technology becomes widely available.





There are many solutions which do not use such high end technology. One common tactic for commercial pilots is to use a checklist to make sure that all necessary tasks have been performed before takeoff. The ideal vs. real takeoff scenarios are depicted above. As in cooking, the process becomes non linear, especially when multitasking. Checklists are not common in home cooking, but have potential to help avoid mistakes when preparing complex recipes. With a digital touch screen device this could be easily and cleanly implemented. Research carried out by Loukopoulos et. al.[29] aimed at improving

flight safety suggests that using tactile methods as oppose to verbal can help pilots focus on overall task management and that the checklist should be as streamlined as possible, but still include items that are most likely to be forgotten.

Another method ubiquitous in the cockpits of modern aircraft is the use of artificial cues to warn of uncompleted tasks or environmental changes. A similar technique is used in the kitchen in the form of the oven timer. It was seen in the observational experiments that mobile phones can also be used to help the cook remember when they next need to act. As well as these the cooking process itself can provide numerous natural cues – the sound of a pot boiling over, or the smell of burned toast under the grill. A more advanced system to augment the naturally occurring reminders, comparable to those used in commercial airline cockpits, could help to reduce the rate of distraction.

It is relevant to look at the technology aircraft use to convey information to the pilot in the most convenient way possible. Cockpit design, especially in fighter jets where space is limited, is moving towards the use of 'soft keys': digital touch screen displays that can show relevant information at the relevant time.[30] Due to the parallels between the environments, similar technology could be useful in the kitchen.

Another way of looking at the problem was to think about how distractions could be minimised. However this presents a social problem as it presumes that all distractions are negative. During the observational experiments, it was seen that a number of 'distractions' were in fact positive experiences such as interactions with friends and family. These acted to enrich the cooking process on an emotional level, even if they detracted from it at a practical one. For this reason it was decided that minimising distractions was not in the best interests of the project as it would not improve the overall experience of cooking. From an experiential point of view it was better to effectively manage any distractions that would arise.

3.1.3. Inefficiency and Flow

This section is linked to distraction. Forgetting what you are doing or where an item of kitchen equipment is can interrupt flow and slow down the cooking process. This happens most often when the cook is preparing a more complicated meal and thinking about many tasks at once (or is distracted, as described above). The MIT Augmented Reality Kitchen has addressed this directly. Using advanced sensing techniques to detect what a user intends to do, the system provides cues such as illuminating cupboard handles when it senses the user is hesitant[31]. This level of technology is not currently viable in a commercial product, but scaled down versions of the concepts used in this project could be useful. From the interviews it was ascertained that sometimes the most enjoyable way to cook is to be, as one interviewee described it, completely 'In the zone' – not having to consciously think about what you are doing, but acting purely on instinct. This is comparable to dancers, often saying dancing is most enjoyable when lost in the music[32]. Psychologically this can be explained by the difference in how the brain processes learned tasks and new tasks. Previously learned tasks are processed in a different part of the brain using procedural memory, as oppose to explicit memory, which requires more conscious attention. However for a task to be stored in a person's procedural memory it must be practiced[33]. This links back to experimental research carried out at the start of the project, using unfamiliar textures to encourage storage of energy saving tasks into implicit memory.

If a user could be guided through the recipe in a subtle way, so that they could pick up cues if needed but would not be disturbed if they were already 'In the zone', flow of tasks could be improved. This method could also help to move tasks from explicit memory to procedural memory over time. Both of these solutions act to make the cooking process more enjoyable and less stressful. This evidence backs up the insights from the cooking lesson, described in the experience section of the report above.

3.1.4. Inexperience

Inexperienced cooks can find cooking more stressful, and inexperience can lead to poor outcomes especially when cooking new meals. Using a new ingredient or trying a totally new technique can end up in the meal being burned or lead to otherwise undesirable outcomes. Every time a 'disaster meal' is made the cook can loose faith in their abilities and be less inclined to prepare something new (or even cook at all) next time. As well as this, a disaster meal is very inconvenient if time has been taken to prepare it and there is no food to eat afterwards. A stressful 'disaster meal' also has the potential to subconsciously give the user a taste aversion to that particular food. Behavioural studies have suggested that implicit memory links negative experiences to flavour aversion.[34]

For these reasons support for inexperienced cooks can be very helpful. One possibility is warning the cook of common mistakes. This could be done in text form as part of a recipe. Better instructions could be provided with multimedia, for example kneading bread is very difficult to explain in text.

3.1.5. Lack of nutritional knowledge

Lack of nutritional knowledge can lead to poor diet, which can in the long term lead to health problems. Even if the user has a good idea of the basic nutritional values of the separate ingredients of a meal, when they are all mixed together and have gone through changes caused by different methods of cooking it can be very difficult to estimate even for a nutritionally aware cook. Because estimating the overall nutritional value of a meal can be a complex mathematical calculation, it is better suited to be calculated by a computer than a human brain. A solution could be to provide full nutritional information with every recipe, or provide scales to weigh ingredients and calculate nutritional values form a database, such as in the Smart counter project[35]. The nutritional values from each meal could be calculated accordingly. Although this might not be a practical solution, the concept of gradually helping users understand the true nutritional value of what they eat in a way that does not negatively affect the experience of cooking and eating is one that could be useful in a design outcome.

There are various health based websites which already aim to aid users in this area[36,37,38]. But again, the same problems exist as with recipe websites, discussed previously. As well as this, many people might not be motivated to go out of their way to find information about health, as statistics about diet in the UK indicate[39]. If health information could be embedded as part of a system that people were motivated to use, this could encourage them to act on included nutrition information.

3.1.6. Ethical

Weather we are aware of it or not, food causes us to make decisions with huge global consequences every day. Food production and consumption affects global climate, economics, animal welfare and poverty levels. Food is also an important part of many religions. Some abstain from certain foods or drinks completely, while others restrict foods on holy days. Practices such as fasting for periods of time are also common.

Personal ethics can complicate a person's relationship with food. This is especially true for newly adapted ethics, such as deciding to become a vegetarian, which can require a huge change in cooking style.

Although listed in the 'problems' section of this report, if a person can effectively eat in a way which they feel is ethical then it can have a positive impact on how they feel about food. For example, fair trade helps poverty alleviation through sustainable development, thus having a positive global impact.[40]

3.2. The Joy of Food

With current food technology it is possible to keep a person alive and healthy with infusion bags[41]. For the vast majority this is a dystopian vision from a sci-fi film, relegated to hospitals and heavily associated with ill health. Gaining

nutrition this way would be easier, cheaper and could contribute to solving various global crises such as climate change and world poverty – meat production causes far more greenhouse gasses than vegetables, and is significantly more expensive[42]. Why then, do we continue to use the more traditional practices of growing, harvesting and cooking our food? Even in space, where meals are considerably more troublesome than on earth, astronauts are given both solid food and hypertonic solutions. This is because food is essential for our health not just physically but psychologically.

Many existing products appear to be focused on people's problems with food and try and eliminate the undesirable behaviours, and the outcomes are therefore corrective technologies. It could be more effective to look at the problem from a different perspective – findings from the interviews indicated that even if individuals had problems, generally they had very positive experiences with food overall. However, the problems people have with food can prevent the joys, so problems and joys are strongly linked. For this reason it was decided that it would be most beneficial to combine a corrective technology with an expansive technology – one which increases the enjoyment and possibilities of interactions with food.

The following sections explain research findings on the positive psychological elements of food and cooking – in order to improve the experience as much as possible it was necessary to identify where the joy of cooking originates from, so the design solution can help facilitate these aspects.

3.2.1. Creativity

For many people cooking is a way of expressing creativity. The dishes of cooks such as Heston Blumenthal are a good example – the nutrition can be secondary to the artform[43]. Pleasure is derived from the creation of something the cook has never made before, or cooking something familiar in a different way[44]. The observational experiments carried out showed that the majority of people enjoy the result of cooking new meals, and are proud to share them with friends and family. In the development of the design outcome it was important not to impede cooks' 'putting their own spin on things', but rather to accommodate this and where possible encourage the practice.

The impact of this on the design of the device is that recipes and the process used to create them need to be adaptive, not adhering to a strict linear flow. Technology needs to be accessed when it is needed, rather than dictating actions to the user. A more suggestive approach would be preferable. If the user could store their own creations or alterations to their favourite recipes in order to then be shared with others, this could encourage the practice of experimentation.

In order to help think about creativity in cooking, a parallel can be drawn with creativity in design. The two areas share a lot of common ground: cooking is essentially designing with food. How do designers get ideas when designing? Techniques I have used in this project include:

Looking at related designs – as in design, related dishes could provide foodie inspiration

Look to history – History can also be a valuable area to inspire creativity in cooking. Heston Blumenthal's 'Heston's Feasts' series exemplifies this.[45]

Look to new technology or materials – as in design, new cooking process and materials can inspire new dishes.

Understanding social context – like designs, food has a social context. Understanding this

could help in the creation of new foods and the surrounding rituals

Unconventional combinations – Random or unconventional combinations of concepts, materials or processes could lead to inspiration in cooking

These methods can be found on IDEO method cards[46]. Using design techniques could help people to be creative in the kitchen.

3.2.2. Memory

Both the cooking and eating of food is a very sensual experience incorporating taste, smell, sight, sound and touch/texture. Even when eating something as simple as a slice of bread all the senses can be stimulated: The smell of the baking, the delight in seeing a perfectly raised loaf, the sound of the crust cracking as we bite into it, the feel of the porous surface in the mouth and the taste, changing over time as the dough is chewed. The combination and intensity of these pleasures is comparable to sexual arousal. Adam Gopnil believes *"A kind of primal scene of eating hovers over every cookbook, just as a primal scene of sex lurks behind every love story.* [47]" The comparison does not stop at the sensual experience – both cause the limbic system to release dopamine.

Using multiple senses simultaneously has a strong ability to evoke emotions and memories. Environments that affect all 5 senses have been found to stimulate the memory of dementia sufferers[48]. Eating a certain meal can trigger memories of a previous time it was consumed. The same applies to the smells of food – for example eating popcorn could evoke memories of going to the cinema. This link was made especially clear during one of the observational experiments where during cooking one of the participants was reminded of a time when she had eaten the same meal when on holiday and asked for the experiment to be paused so she could phone the friend she ate the meal with to catch up.

The enjoyment of the experience of eating is down to much more than the food itself. It can be affected by the eating environment, how relaxed consumers are and the socio cultural connotations of the dish. The social elements are discussed further in the 'social' section of the report.

Other than helping the cook to make the food as delicious as possible by reducing problems and encouraging creativity, how can these external pleasures be stimulated? How can memories and positive emotions be stimulated? *Don't feed the bears* cookbook suggests a different death metal album to listen to with each meal[49]. Other possible solutions could include providing historical information about the meal, or reminding users of the context of previous times when they cooked the meal.

3.2.3. Food as Gift

Food is a gift both literally and symbolically. It is common to give chocolate eggs at Easter time for example. When a meal is cooked for others it can symbolically embody love and caring the cook has for the recipients of the meal. For some cooks, especially parents, very similar thought processes are employed when cooking to when choosing/buying a gift: consideration of what the recipient will like; consideration of the impact of the gift (nutrition); trying to improve the presentation.

Dividing and sharing food often reflects hieratical position within a family or social group. There is a certain amount of power associated with deciding who receives how much food. The sharing of food is especially important in ceremonies – the birthday child traditionally cuts the cake at a party, the couple at a wedding. Cake can also represent one being part of the whole, standing for unity.

Given the symbolic importance of gifting food, how can the gifts be more symbolically charged?

One concept derived from this idea was as so: for every meal cooked, the user could have the option of having an artefact produced to remember the meal by. This could be 3D rapid prototyped, or be something much simpler like a printed photograph of the diners. Another

concept dealt with digital archiving of the meal – this could be done through photographs or through audio. This information could then be displayed next time the user is cooking, or throughout the day in the kitchen. Concepts such as these could help lone diners feel more social connectedness by reminding them of meals shared with others.

3.2.4. Social

In a busy household an evening meal can be the one time of day where a family will all spend time together. It can be a social event where families can find out about each others days and share thoughts and feelings, strengthening family bonds. It is also an appropriate context for parents to teach children about food, cooking, nutrition and etiquette. A family is partly defined by its eating habits, as noted in a study by Charles and Kerr[50]. Similar social bonding and structure definition can also happen in non family households or flatshares.

The social context of a meal can completely change the experience. For example a gourmet meal alone may not be as enjoyable as a pot noodle among friends.

Recipes have a cultural value and the transfer of recipes can help to establish family or group identity. Communication of artefacts such as recipes is therefore very meaningful on a much deeper level than food. If this communication could be improved it could reinforce social bonds.

Both research and commercial projects have dealt with this area. Keyingredient.com, described earlier in the report, has social functions such as a recipe sharing and rating system. Kitchen Album is a research project allowing users to transfer recipes via audio. In these and other projects with social features, the focus is on directly transferring recipes to others. However, other methods of evoking social connectedness could also prove beneficial. These could include information such as who else is cooking food now; what your family, friends and community cooking; who is eating the same food as you and what recipes are popular in your local area.

3.2.5. Relaxation

As explained in the problems section, food preparation has the potential to be particularly stressful. However for some, cooking and eating are methods of relaxation. Many of the physical actions used in cooking can be therapeutic, for example kneading dough. During the experiments it was observed that people like to do other things while cooking such as have a conversation, watch TV or listen to music. These actions can add to the calming nature of cooking, as well as emotionally enriching the process. The act of eating food can also be relaxing. Eating or drinking often forces people to stop what they are doing and have a few moments to themselves.

Many of the ways to enable relaxation involve removing problems with the cooking process, discussed earlier in the report. One way to enable relaxation further could be to enable the design outcome to play the users' favourite music or chat to others online through a service such as Skype.

3.2.6. Trend Seeking

Around 10,000 food products are launched every year. 50% fail within 3 months and only 5% will remain on the market over 2 years[51]. Like clothes, different foods fall in and out of fashion. Food trends are often set by media outlets such as TV cooking programmes. The popularity of many styles of cuisine or ingredients in supermarkets

can be greatly affected by their use by celebrity chefs[52]. New food trends predicted for 2010 by Mirian Salzman, global head of PR at Euro RSCG, include an increase internet shopping, slow cooking, and immunity diets[53]. The constantly changing nature of these trends, which include ingredients and processes, can influence people to try new dishes.

Despite the seemingly fickle nature of food fashion, trend seeking can be a beneficial force in people's relationship to food. If a person was to be inspired by a chef on TV or cooking programme and this helped the person to take a greater interest in cooking, to cook healthier food, or to be more creative, then the effect has been positive. If a device could help the user easily act on these inspirations, then it could improve the users' relationship with food.

One example would be a product which generated a shopping list for a recipe seen on TV, which could then be ordered online. Currently existing examples include Jamie Oliver's recipes for Sainsbury's supermarket, which can be accessed online and the ingredients ordered through the website.[54]

3.2.7. Cultural

Food speaks. Over its basic purpose of nutrition, it tells us a huge amount about the social relationships existing among people when they eat and can represent the symbolical universe of whole communities. Food such as the communion wafer in the Christian church has basically no nutritional value, yet the practice of eating it still exists. This is an example of food which is pure symbolism – its function is purely cultural. These foods reinforce our personal, religious and social identities. Works by anthropologists such as Levi-Strauss' *The Raw and the Cooked* have discussed at length the importance of food in defining cultures.[55]

How does food attain cultural value? In many cases it is linked to tradition, history and geography of a group of people – fish and chips is considered a British dish, for example. Food can also attain cultural value by representing ideals, lifestyle or politics. In the Futurist Cookbook, many of the dishes are inspired purely by Futurist political ideals, stating *"men think, dream and act according to what they eat and drink."*[56] the book caused uproar for total rejection of the use of pasta, a staple in the Futurists' home country, Italy. Recipes in the book include the Chicken Fiat: A chicken roasted with a handful of ball bearings inside. "When the flesh has fully absorbed the flavour of the mild steel balls, the chicken is served with a garnish of whipped cream."[57]

The cultural connotations of food are not necessarily positive. Fast food is used as an integral symbol of North American culture, often with the focus on the negative connotations of obesity, aggressive globalisation and exploitation[58,59]. Foods can bypass positive symbolism and cultural reference. An example of this could be a supermarket 'ready meal'. However, even with meaningless food, the situation in which it is eaten can create meaning. A communion wafer eaten outside of church or a religious context, or by someone who did not understand the underlying cultural value, can loose all symbolism. In the same way food previously without symbolism has the potential to gain cultural value, as it is purely a mental construct.

How can a product help food to attain positive cultural value? How can pre existing symbolic value be communicated to the user, or re-enforced? One possibility is to allow a cook access to information about what people in their local area are cooking, or what people with similar interests are cooking. This could attach

increased cultural value for a given dish, helping the cook to feel part of a larger group of people.

3.3. The kitchen environment

It was important to gain an understanding of the context in which the outcome was to operate. Part of the purpose of the observational experiments was to gain a better understanding of how people interact with their kitchen: what they do there; how they move around; where different appliances or utensils are stored; how they are used; what equipment is most commonly used. Other questions asked for this phase of research included:

-*How do people use the kitchen? How does this differ in different countries or among different groups of people? What impact does this have on the design outcome?*

-*What qualities do successful kitchen products have?*

-*Is there a set kitchen aesthetic? How firm is it? What defines it?*

-*What conditions is the product likely to encounter? How can it be made durable?*

-*How do commercial kitchens differ? Are there any principles used in commercial kitchens that can be transferred?*

As well as a place for cooking and eating the kitchen commonly acts as a hub for family life. This is especially true in open plan kitchens/living rooms. The design outcome needed to support the social rituals of mealtimes.

Many dishes such as fondue have an associated ritual, and the paraphernalia is an essential part of their acceptance. The importance of alternative foods often lies in the process of their production. In other words, meals which require unique, characteristic and curious objects can become popular. The prevalence of the cooking of Heston Blumenthal is an example of this, using processes such as vacuum jar and sous-vide cooking. Kitchen objects indicate actions and can dictate how a meal is played out as well as how it is experienced.

In order to understand the draw of kitchen items I conducted an analysis of a number of kitchen products deemed to be 'classic designs': those which were popular because of their overall design rather than functionality alone. This is included in appendix 3.

Aside from their functionality, it appeared that the most popular designs had a perfect balance and interaction of traditionally masculine and feminine design elements: curves and geometry, soft and hard materials, technology and charm, practicality and decoration. A kitchen aesthetic is largely defined by a palette of commonly used materials, however is not strictly defined in terms of form. The layout of the kitchen in the western world has become relatively uniform since the development of the "Frankfurt Kitchen" in the early 1900s, the first standardised kitchen design[60]. However there are many styles of kitchen including contemporary, rustic, minimal

and many more, too numerous to list. This separation of styles transfers to product design of artefacts within the kitchen. The difficulty here is designing a device which can look at home in as many of these kitchen styles as possible, if that is what is required.

In order to be durable, the design will have to be able to survive spills, splashes, relatively high operating temperatures, exposure to sunlight and knocks from other kitchen equipment. The outcome will also have to be easy to clean and should not allow dirt or dust to be harboured in any crevices.

3.4. Cookbooks and Recipes

The study of recipes was important for understanding the connotations of how the cooking process is communicated. It was also necessary to determine what information needs to be transferred for someone to be able to cook a new meal, and the most effective way for it to be presented. This information was found through the study of numerous cookbooks and historical cooking instructions. A summary of the history of recipes and a list of different genres of cookbook and what defines them can be found in the appendix 4.

The analysis shows that changing how recipes are presented and the medium they are presented in has the potential to affect their symbolic value. This is an important consideration in a cooking device. The same recipe can have a different meaning when depicted in a different way, or in a different medium. Considering that people will mostly only cook 2-3 dishes from each cookbook purchased[61], it seems strange that there is so little focus on making the recipes that are cooked more of a rich experience. Learning from simple, functional cookbooks can often skip the social element – meaning the cooking education they provide is lacking.

The use of video or multimedia recipes has the potential of adding a social significance, especially if content is created by family or friends. The ability to customise the style of a recipe layout, or add additional background information about the food, can work in the same way.

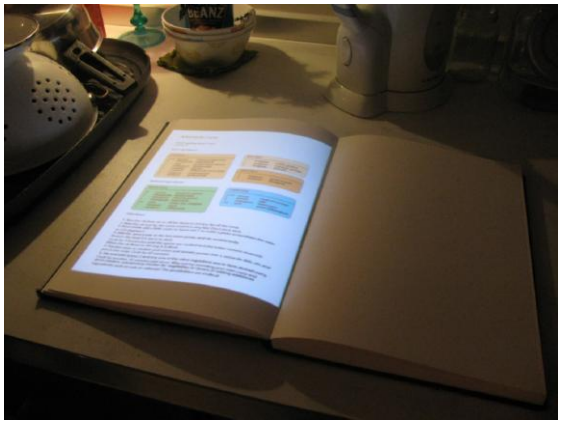
3.5. Research Summary

As explained above there are a wide range of different pleasures and problems that define each person's relationship with food and cooking. The interviews showed that despite the existence of loose typologies, individuals are affected by a unique combination of the above factors, and more. Given that no solution will be attractive to everyone, in order to appeal to as large a group as possible the solution’s function needed to be adaptable and customisable.

4. Development

Concept development was carried out at the same time as research, as many ideas were generated during research. The first stage was to generate 'blue sky ideas'. At this stage practicalities were not important; the aim was to explore possible physical manifestations of the insights gained during research phase. The principles of conceptual designs could be carried forward to more practical solutions at a later stage in the project. Here I will present a few of the ideas which helped lead to the final outcomes.

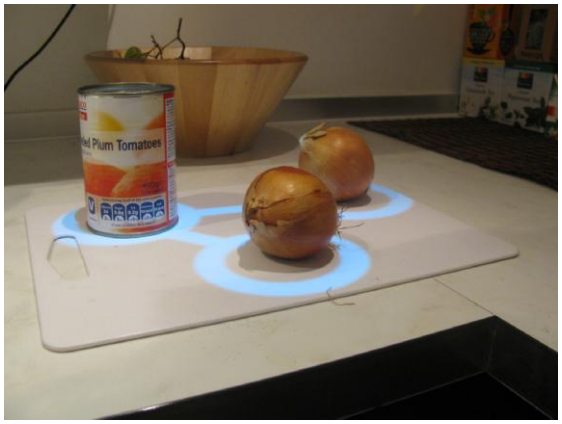
Initial concepts – cookbook



This physical sketch depicts one of the questions that spawned the project – what if a cookbook could give you a greater depth of information, but only display what is relevant?

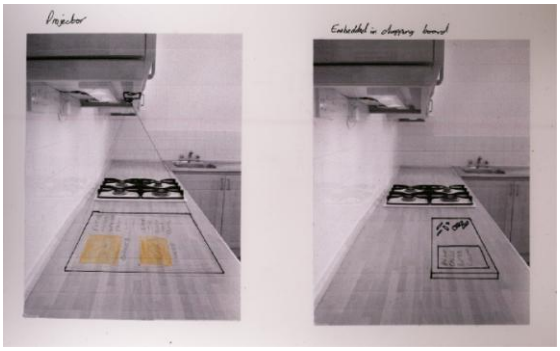
Initial concepts – chopping board

Here I was trying to explore the idea of weather dynamic direction using projection would be a better way to be guided.



Initial concepts – food capture

The idea here is that you can place the food on the board and the system will detect what it is and give you possibilities of what to cook with it.

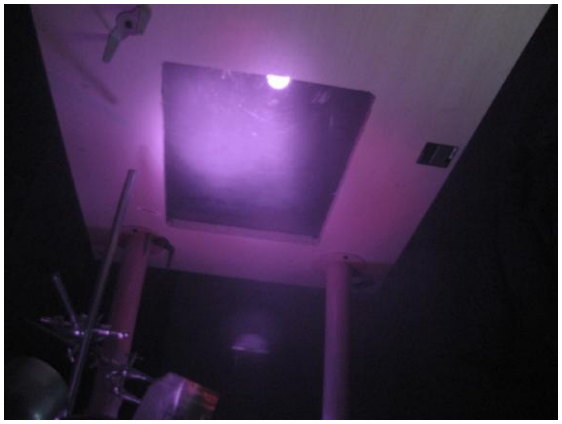


Initial concepts – sketches

The next stage was to refine these blue sky ideas into something that was achievable within the given time for this project, and met the aims and specification as dictated by the research phase. These are the sketches that I chose to develop.

In order to evaluate some of the initial concepts a test rig was constructed, comprising a touch screen and various cooking accessories to aid organisation. An image was projected from underneath the table onto a frosted acrylic screen. The user could interact with this image using a multitouch system called direct illumination (DI). DI is a visual method for detecting touches on a transparent rear projection surface. It works by flooding a transparent surface with infrared light, and viewing the reflections with a camera. The position of the reflections (i.e. finger touches) is determined by the software. The downside of this is that camera and infra red lights need to be positioned under the surface, which would take up valuable kitchen space. The advantage is that there needs to be nothing above the work surface, so the worktop is left uncluttered.

The method proved unreliable. The reasons for this were patchy illumination and glare, both shown in the infrared image below. This setback meant that due to time constraints the final outcomes had to be decided without user testing. Instead of continue to refine the method I decided to find a new way to detect touch which would be more practical in a kitchen environment.



5. Specification

This section will summarise the findings of the research and development into specific requirements for the design outcome.

The outcome needs to:

- Provide instructions for users on how to cook new dishes

- Provide inspiration on what to cook

- Provide nutritional and dietary information

- Be pleasurable to use

- Not interfere with the flow of the cooking process, and where possible improve flow

- Be intuitive

- Be durable in a kitchen environment

- Cater to a range of cooking abilities

- Have the ability to provide cues when needed

The outcome should:

- Encourage forward planning of food shopping

- Encourage organisation of cooking process

- Have access to a large variety of recipes

- Include an effective recipe search

- Include a number of search criteria, including social criteria

- Not be reminiscent of a computer, even if similar technologies are used

- Present information in a relaxing way

- Provide a checklist of key tasks

- Not interfere with the user's direct interaction with food

6. Outcomes

The project resulted in 2 outcomes. Both devices have the same aim and perform similar tasks, but take different physical forms and use different technology. One solution requires developments in technology to become commercially viable, but has the potential for its use to become relatively widespread. The other uses current technologies to make an upmarket product.

6.1. Chefmate

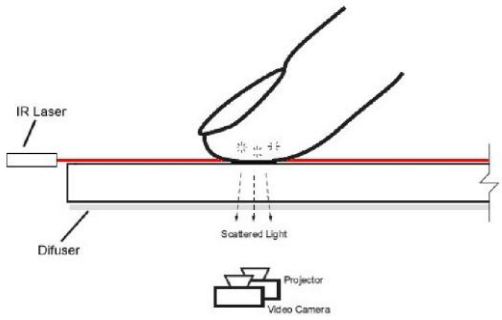
The Chefmate is a tabletop device which helps people to cook new and memorised meals at home by interactively guiding users through recipes. It also has social features to enrich the cooking experience, and can help the user organise their shopping. It achieves these aims by projecting the recipes and other useful cooking information onto a silicone chopping mat. The user can interact with the projected information by pressing the mat, with a similar action to touchscreen devices such as the Apple iphone. Using a Wi-Fi connection, the user can update their recipe collection, share recipes with friends or purchase food from the recipes on the device online. The software interface is discussed in greater detail later in the report. For the purposes of this project a proof of concept model and an appearance model were made to evaluate the design.

The device is designed for beginner or mid skill level home cooks with an appreciation for good food. It is not designed for people who do not enjoy food and see food just as a fuel. Likewise it is not designed for high skill level cooks who do not need recipes or advice on how to go about meal preparation. The device combines solving the problems identified in the research phase with encouraging the attaching of positive emotional value to meals.

6.1.2. Technical aspects

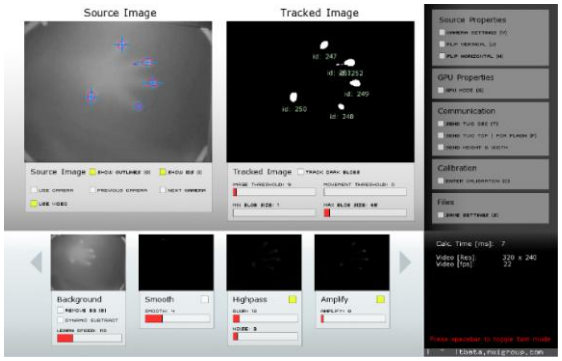
The Chefmate requires no installation. It just needs to be placed on the counter and plugged in. As long as the surface is relatively flat the device will be ready to go once it receives power. Because the projector and camera are always a set distance from the screen, and the lasers are always parallel to the work surface, the unit needs no focusing or calibration.

To turn on the Chefmate, the user need only pull up the mirror. This reduces the number of actions the user has to enact, making the whole process simpler, and startup quicker. The device will shut down when the mirror is closed. The device will automatically go into a low power mode or shut down if not used for a certain amount of time, definable by the user in the device settings. The Chefmate will encourage the user to put the mirror down, as the mirror also acts as a lens cap, so closing this will reduce the amount of dust that will accumulate on the lens, as well as reducing energy use.



The LLP system used in the Chefmate can process multiple touches at one time, unlike many common forms of touchscreen. This allows for gesture detection. Gesture detection can make more complex functions, such as zooming into pictures, much easier to access and more intuitive. LLP works by shining a plane of invisible infrared laser light a few millimetres above the touch surface.[62] A camera is pointed toward the touch surface, so that when the plane is penetrated, light is reflected towards the

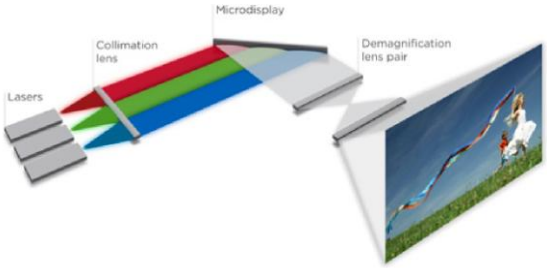
camera. The camera sees this reflection as a blob, and software can locate the position of the blob and send data over TUIO protocol.[63]



This means that each touch can be interpreted in the same way as a mouse click by software such as flash or processing. In the working model, a PS3 camera was used because of its low cost and high frame rate. High frame rate is essential for smooth performance of the system. Low frame rate causes actions such as dragging to be jumpy, and some quick touches not to be detected at all. This was combined with a laptop computer. In production, this system would not need a dedicated computer. All of the software could be contained on internal hardware, in a system similar to that used in advanced digital photo frames.

During the development process, a range of camera lenses were tested. Wide angle lenses allowed the camera to be closer to the reflected image. This provided the benefit of being closer to the reflected light, making it more intense and easy to detect. However the down side was that the image was significantly distorted at the highest angles, causing inaccuracy when detecting the position of the reflected laser light. In the end the lens angle was dictated by the position of the camera, next to the projector lens. The lens was chosen so as to make the camera's area of vision the same as the touch area.

A 780nm band pass filter was added to the lens, the same wavelength of light as the lasers emit. This only allows the frequency of light emitted by the laser through to the camera. The purpose of this was to stop interference from other light sources, including the projected image. Before this, interference from sunlight had been a problem, as kitchens are often very light rooms. Sunlight contains infra red light, which lowered the signal to noise ratio, resulting in touches being less accurately recorded. The filter completely removed this problem, despite extra expense.



The system uses HLP projection technology. HLP works by shining 3 lasers through a diffraction pattern, forming a high quality image[64]. HLP is ideal for the kitchen environment as it will stay in focus on a bumpy surface, and can project onto any medium. This means spillages or surface contaminants on the chopping board will not greatly affect the image quality. HLP requires significantly less cooling than DLP or LCD. This allows the wooden casing to be used without fire hazard, and requires less ventilation.

Because the projector, mirror and screen are at an angle, keystoning occurs. Keystoning when a projected rectangular image becomes a trapezoid because the light has to travel further to some areas of the screen than others. If keystoning has to be corrected for digitally, the image will not be as clear and artefact free, because mathematical calculations used in this process are not 100% true to the original image. This problem can be alleviated with a shaped mirror. An example of this is the Hitachi extra short throw projector. In the working model developed for this project, digital keystoning is used. To have a mirror specially shaped was out of the scope of the project, taking in to consideration the relatively small benefit it would provide to the image from a low cost projector. However depending on the exact projecting technology used, a shaped mirror could be of benefit.

The size of the unit was dictated by the required size of the screen. The optimum screen size was derived from initial tests on the working model. Given the required image size, the required throw ratio of the projector could be calculated for given distances from the screen. The aim was to maximise the throw ratio. The reason for this was that projectors with higher through ratios are mostly more compact, or lower cost, or both. The optics required for higher throw ratios cost less. In order to minimise throw ratio, the distance between the mirror and the screen had to be as large as possible. The problem here was that the further the mirror is from the lens, the larger the mirror had to be. A compromise had to be reached between distance, device size, mirror size and throw ratio. Various solutions were tested by making cardboard models, to get a feel of how each solution might work. Using a mirror built into the device would have made it very large, or have a high throw ratio. So in order to decrease the size of the device the solution was to use a folding mirror. Using an external mirror would have required installation, or calibration/focus of the device. The folding mirror allows the device to be more compact and less visually obtrusive when not in use.

The other factor possibly dictating the size of the device was the location of the lasers. They had to be positioned so as to cover the whole screen area, and be no wider apart than the intended size of the device. The minimum distance between the lasers to cover the given screen size and still reduce shadows as far as possible was roughly 210mm.

6.1.3. Materials and manufacture

Ash wood was chosen as it is a common material to be found in the kitchen, and fits into numerous different kitchen styles. It gives a more natural impression than plastic, a more common material for housing electronics. This is to make the digital element of the device less obvious – to aesthetically distance the device from computers. The purpose of this was to not alienate people who would not be comfortable using computers, or who would not be comfortable with using a computer in the kitchen. The outer skin was finished in matt polyurethane varnish. This preserves the natural look and feel of the wood whilst providing a protective coating and waterproofing: essential for kitchen use.

The chopping board is a foldable silicone matt. Its large size meant that it would not be practical to try and wash such a large traditional chopping board – it would not easily fit into most sinks. Testing of a number of materials showed silicone is an excellent projection surface, offering a high gain and good quality image. Another advantage is that cuts to the screen from kitchen knives would be more effectively hidden than other chopping board materials such as polypropylene. Cuts would change the topography of the surface and lower the clarity of the image.

The device would not be difficult to manufacture, there are commercial products with similar constructions. Wood elements could be machined on 3 axis milling machine. Plastic elements could be injection moulded. The projector and some of electronics including laser units would most likely be purchased as OEM parts. Mirror acrylic could be CNC cut from sheet.

It is difficult to gauge the potential cost, as previously stated, because the device requires currently existing technology to lower in price to become commercially viable. However it is estimated the device could retail at roughly $350, based on the price of existing table top projectors, optical touch screen systems and digital devices.

6.1.4. Safety

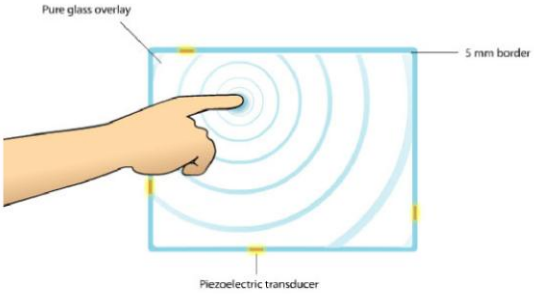
Laser safety was a problem during development, as the device was to contain a total of 5 laser diodes. The device was engineered so that it was class 1, safe in any circumstance given reasonable use. The calculations used to achieve this are contained in appendix 5.

6.2. Chefmate Hob

The Chefmate Hob has the same purpose as the Chefmate, but takes a different form. It comprises of an induction cooker and a touchscreen monitor. It has a similar construction to existing glass top electric hobs, except with an extended cooktop to allow for the touchscreen. The touchscreen element consists of a wide screen monitor mounted in portrait below a section of DST glass, sealed in with a border of silicone to protect against spillages. Like the Chefmate, information is transferred to the product over Wi-Fi.

DST (dispersive signal technology) is a touchscreen which uses piezoelectric sensors to detect vibrations in a glass substrate. The system works out the position of touches from the generated signal. The advantages of this technology over other methods are that it ignores spills or surface contaminants – other direct touch methods such as capacitive do not. Because it works by vibrations the system will ignore static objects on top of the surface. The system is very sensitive and can ignore impacts from non finger touches. The glass surface is chemically resistant. These factors combine to make it ideal for kitchen use.[65]

The glass ceramic used for the main body of the cooktop is to be a material such as Ceran. This has a thermal shock resistance of up to 750 degrees Celsius, low thermal conductivity and low thermal expansion. It has previously been used for induction, halogen and radiant hobs.



A stainless steel rail acts as a visual divide. This is for safety to make it clearer and more intuitive to the user which area is the hob and which is the cooking aid. It also acts to break up an otherwise large area of black glass.

The user controls are simple to use, and use capacitive touch technology. This is cheaper than DST. Because it only needs to detect simple yes/no touches this simpler method can be used. The use of touch controls allows the cooktop to be flat, giving a sleeker, more minimal appearance. These controls are laid out in a way which is designed to be intuitive, touching the position of the hob the user wishes to control and then heat higher or lower. A power button is separate. Visual feedback about the heat is given in the form of number.

The unit would be no more difficult to install than a normal hob, although it would require an additional mains power input. This would not be a problem in the majority of kitchens. The

worktop can be routed to a template and the hob sealed in with transparent silicone sealant.

Induction cooking was chosen over electric or halogen because it is more efficient. It is also more expensive; however the product is designed to be for high end kitchens, as the touch screen will increase the price above that of a regular hob. Although gas is a more energy efficient way of cooking in terms of greenhouse gas emissions, the overall appearance would be less balanced due to grills and gas outlets on the cooking side of the system, and a flat screen on the other. Gas would also detract from the 'magic' of the product – a flat black panel with hidden functions gives a very different impression to a gas hob.

The cost of the device is difficult to estimate, however based on current retail prices of large induction hobs, DST touchscreens and advanced digital photo frames, the product could retail at around £2000. For comparison, upmarket induction hobs retail for up to around £1500. The increased cost is largely down to the high price of DST technology.

6.3. Software

Both devices use a similar software interface. It allows the user to:

- *Access a database of recipes*

- *Search by name, ingredients or course*

- *Watch video tutorials to show more complicated techniques*

- *Input and share user recipes*

- *See what recipes friends or family have been cooking*

- *Recommend recipes to friends/family*

- *See what recipes are popular in the user's geographical area*

- *See most popular recipes*

- *Have the software recommend recipes based on what the user has cooked before*

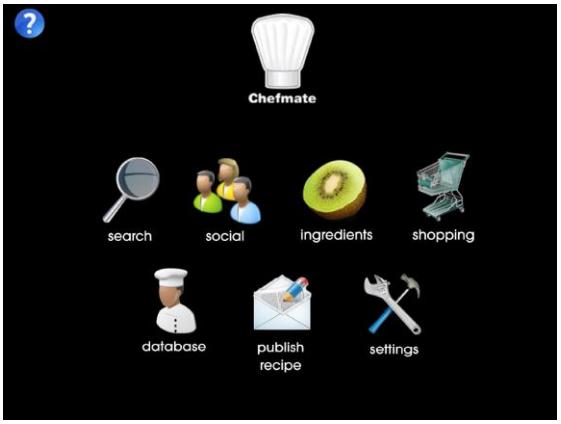
- *Choose the coming week's recipes and put into shopping list*

- *Order this food online for delivery from a number of retailers*

- *Compile digital cookbooks to send as gifts via email*

- *Order printed copies of digital cookbooks to give as gifts*

It is designed to help deal with problems outlines in the research findings, and enable more emotional meaning and enjoyment from a meal. Due to time and resource constraints, writing of the software was not completed; however a plan of how it would look and operate was formed.



The interface is designed to be simple and non-threatening to people less familiar with computers. The background is black, meaning nothing is projected on the Chefmate. Icons and buttons will appear as small lights which the user can press. On the Chefmate hob icons appear against a black background.

The most commonly used functions are on the home screen, in order to facilitate quick and intuitive operation. Icons help quicker identification of functions.

The recipe screen shows a number of steps at a time, as well as the ingredient list. More information about the steps can be accessed if needed. A checklist helps make sure everything is done. Timers can be added as needed. These are to improve the flow of cooking a new recipe, and not dictate when steps are to be carried out, allowing the cook to work at their own pace or put their own spin on things. If the user is unsure of a step they can access more information, helping with uncertainty and lack of skill. This system also allows for distractions and helps the user get back on track if distracted, as described in the 'distractions' section of the research. Nutritional and ethical information is also available, as informed by the research findings. The devices have the potential to engage children in the cooking process through graphically rich interactive multimedia recipes.

Recipes and information can be searched easily using a wide range of both practical and social criteria. Factors include by ingredient, by area or by friends and family. This allows for both practical and emotional value to be added to the meal, or a combination of both if a number of search criteria are used. Searching is done with an onscreen keyboard and auto complete with icons. This is a similar system used to speed up self-checkout machines at supermarkets.

The ability to compile digital or physical recipe books can enrich the experience by helping the user feel more socially connected to the recipient (if they choose to gift it). It also draws on the memory area of the research – cookbooks can trigger memories, especially if compiled from poignant previously eaten meals.

Both products allow the user to shop for food online in a similar fashion to the website mySupermarket. Ingredients can be added to the cart straight from recipes, adding a level of convenience for the user.

MySupermarket derives its revenue from two sources: The first is targeted advertising based on the user's shopping cart's contents. The second is a data service provided to the retailers and merchants which includes price listings, inventory listings and a comparison and analysis of products sold within the UK grocery sector. The Chefmate could offer a similar information service – information about what its users choose to cook could be valuable.

The company claims an average online grocery cart includes approximately 50 items, with a total cost of £80-110. Given that many online food retailers offer an affiliate scheme to advertisers, offering royalties of up to £10 per shop made through affiliate websites[66]. Any shopping done through the Chefmate could be a lasting source of income for the company that produces it.

7. Evaluation

It is difficult to quantify the sucess of the project. This is because of the subjective nature of the brief and aims of the project, and the lack of user testing carried out. Although the outcomes are mostly based on principles which have been used

in other fields, how well they transfer to the area of cooking remains untested. Also the effectiveness of the final design in fulfilling the more subjective areas of the aims and specification requires testing to evaluate effectively.

Many of the features of the project were based on observations of a small number of people and backed up with other academic studies which have not proved their value in a commercial field.

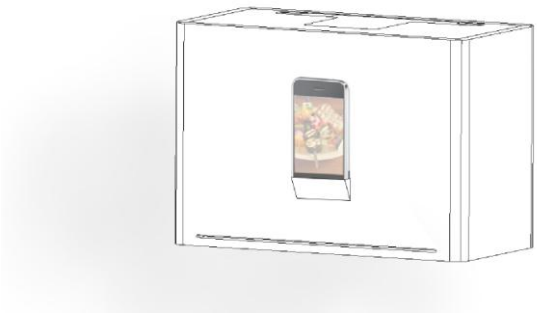
However the practical elements of the brief and specification were met – a device to aid people in the kitchen environment was produced and shown to function through a proof of concept model.

There are various issues with the planned software that would need to be solved through testing and improvement. Combining recipes to make a meal is currently not factored in but was found in the ethnography to be a common way for people to cook, for example 2 curry dishes and rice. Font sizes and icon sizes need to be tested for functionality.

Weather the device ultimately succeeds in the aim of improving a user's relationship with food would need large scale user testing to quantify.

8. Further Work

One factor that was not considered at the beginning of the project was the potential for similar devices in commercial kitchens. Many fast food restaurants such as Mcdonald's have a high turnover of unskilled staff and training is essential for a well run restaurant, and is a significant cost. New additions to the menu may also require novel techniques or equipment. A device similar to the Chefmate could be used to guide staff through new procedures, reducing mistakes and saving time and money. A similar device could also be used to train more traditional skilled chefs from a beginner to intermediate level.



If the devices could harness the processor and Wi-Fi connection of a smartphone, they would need less dedicated hardware of their own. This would lower the cost of the devices. The drawbacks from this are that smartphones are far from ubiquitous, and they do not all use the same operating system. However, a device such as the Chefmate could have potential to be used for a wider range of applications including games, maps and web browsing. Developing a system such as this was out of the scope of the project due to the complicated electronics and software programming involved, but has potential for further development.

There is also potential for a similar device to be specifically aimed at children, not just to aid cooking, but to aid learning on a wider scale. This is touched on earlier in the report. The links between the design outcome and touch screen technology designed to teach children in museums are strong.

If the Chefmate project continues, the next stages are to further develop the software to a point where the working model can be used to evaluate the effectiveness of the product in fulfilling the aims of the project. This can then start a cycle of testing and improvement. Simultaneously the projection methods and optics need to be finalised in order to combine the functionality of the working model and the appearance prototype. For the Chefmate Hob, DST touchscreen needs to be tested for the application, in line with software development.

Appendices:

Appendix 1 - Ethnography procedure

Interviews: I interviewed a number of people with differing lifestyles about their attitudes to food and cooking. This was at an early stage in the project, before the brief had been set. The purpose was to try and understand the areas people have problems with food, and the areas from which they derive joy. These findings could inform the direction of further research. The interviews were carried out within participants' homes. Where possible participants were interviewed in pairs or 'dyads'. This was so that the pair could bounce off of each other and make the interviews more of an informal dialogue than a one on one question and answer session. The informality was intended to help the participants relax and be more honest about their feelings about the subject. At this early stage in the project there were no set aims for the interviews other than to perhaps generate some insights that could be researched further. These interviews were videoed for later reference, in case information which did not seem important at the time later became relevant.

Experiments: The first experiment was to observe 8 people cook the same meal. The purpose was to see how their processes and their outcomes differed, and help to highlight areas where there is potential for a new technology to improve the experience. As well as these primary purposes, there were more practical secondary observations, such as how people use their kitchen equipment, how they move around and how long they spend on various tasks.

The participants were selected from the interviewees who were deemed to have the most differing attitudes to food, based on their responses in the interview to how important a part of their lives food was and for what reason. The aim was to observe cooking at its most natural, with uninhibited participants. This was done in people's own homes so that confusion about a new environment would not affect their cooking. The participants were all provided with the same ingredients and the same recipe printed on a sheet of A4 paper. Ideally it would have been better to provide the recipe beforehand and allow the participants to purchase their own ingredients so unfamiliar brands did not make the cooking process more unnatural. However given that there was no incentive for the participants this would have been too time consuming, so all the ingredients were provided. The age of the participants ranged from 18-62 and included British, Japanese, Chinese, Israeli, Greek, Italian and French nationalities. Although the fact that many of the participants were friends or family may have limited the range of the findings, it had the advantage of helping the participants relax, and cook very naturally without inhibitions.

Following this experiment I used a similar procedure and asked 2 of the participants to cook a recipe which I knew would be problematic, too identify how they dealt with the stress of a recipe going wrong. The purpose of this was to see potential areas where product would be most useful, either in helping the user through difficulties or in avoiding the problem all together.

Appendix 2 - Reasons for uncertainty

Poorly stocked kitchen: This is a common scenario where a cook does not have enough ingredients to prepare meals for which they have memorised the recipe. More experienced cooks can often make up a recipe from unfamiliar ingredients, as can be seen in TV programs such as Ready Steady Cook, but

less experienced cooks could lack the required skill. Internet recipe websites can be useful in this situation. It was found that less experienced cooks generally had more poorly stocked kitchens. This would suggest that a well stocked kitchen is part of cooking skill (or perhaps a pre-requisite). A solution to this could be helping the user to organise their kitchen stock so that the situation does not arise as often. For example planning meals on a weekly basis and then printing out a shopping list or ordering online would in theory mean that the kitchen was never without necessary food. This would be unlikely in practice, as a strict schedule could be restrictive, but could help greatly reduce the occurrence of a poorly stocked kitchen.

Lack of cooking knowledge/experience: Lack of cooking experience can lead to problems during cooking (especially unfamiliar dishes), or uncertainty of what to cook in the first place. A solution to this could be an easily accessible database of information, or warnings for when things are about to go wrong. A set of memory cues can help remind the cook to perform various tasks.

Guests have specific dietary requirements and an unfamiliar style of cooking is needed: sometimes unfamiliar dishes require a whole new style of cooking. For example, vegetarian cooking is different to cooking meat dishes. Again, common solutions to this problem are internet recipes and cookbooks.

Want too cook something that someone else will like: Trying to guess what someone will like can be difficult, and require the cooking of unfamiliar dishes. A solution to this could be a searchable database where the user enters other likes of the intended recipient. Currently recipe searches only offer practical search criteria, but social search criteria such as hobbies, or other meals they like, could help the user to choose.

Want to try something new but don't know what to do: Another possibility is that an individual has become unsatisfied with their current repertoire of dishes. In this situation it is common to browse a cookbook or an internet recipe. If the cook can not find a new recipe easily enough, they will revert back to a recipe they already know. This is often affected by outside constraints such as tiredness or lack of available time for cooking. A solution allowing easier access to new ideas than current recipe finding methods could help users to realise their desires to cook new meals more often.

Deciding what to cook for a dinner party: trying to consider what a number of guests will like, as well as offering a dish suitable for the occasion. The SuChef study also finds a difference between everyday and performative cooking. [67]

Balancing the needs of everyone in a family meal: Catering to the needs of a family with different dietary requirements and taste preferences can be a problem. A recipe database with a variety of search criteria could help with this problem.

Appendix 3 - Product Analysis

9093 Kettle
Michael Graves for Alessi, 1985

Alessi's best selling product, even with high price tag of $100
Many related items followed
“Architectural and product designs have a narrative capacity – you can start to tell a story about them

and imagine a lot of things. The Alessi bird kettle has a personality, with its simple geometry. Its dots on the bottom are red to signify heat as it's placed on the stove. And the shape of the grooved handle, which is blue where it was cool to touch, and, of course, a bird whistles"
Unremarkable geometry – but ornamentation gives it personality.
Simultaneously playful and sophisticated – responsible for mass market appeal.
Basic colours, add to function.
Bird is a hassle – has to be removed by hand before pouring. Can burn or become lost.
Ornamental exposed rivets – sense of strength and quality, balance ornament so it is not all on the top

Moka Express
Alfonso Bialetti, 1933

270 million sold globally, 9/10 Italian households own one.
Form Comparable to abstraction of female body?
Functional but beautiful. Materials purely functional.
Bialetti logo
Symbolises the point at which café quality coffee could be achieved in the home. Became popular after the fall of fascism. Women gained access to the coffee ritual – previously coffee was mainly drunk by men in cafés. Marketing campaign used modernism and women's liberation to sell the Moka Express. It has become so engrained in Italian culture that the term moka is often used instead of coffee maker.
Achieves similar quality to a machine, but costs much less.

Stand Mixer (model K)
Egmont Arens for KitchenAid, 1937

Arens developed a reputation for designing for the full range of sensory experiences, or "humaneering"
Professional cooks wanted it for quality and flexibility.
Status symbol in the home – makes home cooks feel professional.
Unchanged for 70 years.
Now has retro appeal.
Sturdy, durable quality aesthetic.
Simple, streamlined form.
Colours give a hint of playfulness.
Resembles power tools such as pillar drill.
Intuitive controls.
Different attachments allow a number of functions without adding visual clutter.
Balance of masculine and feminine – sturdy, masculine sturdiness and materials, feminine curves and colours (depending on colour chosen)

Juicy Salif
Philippe Starck for Alessi, 1990
Iconic in the field of product design
Designed as a conversation starter, provokes reaction
Unique form
Functions, but not very efficiently.

Sculptural over functional.
Shows how kitchen has become a place to display art, an integral part of the home, not just where women or staff go to cook at the back of the house. Represents the blur between art and function. Shows cooking as experience and performance.

Appendix 4 – Cookbook Analysis

Evolution of cookbooks

The first known recipe dates back to around 1600BC and was inscribed into an Akkadian tablet found in southern Babylonia. The earliest known cookbook is referred to as 'Apicus', originating from the 4th or 5th century. These ancient recipes were much shorter than contemporary recipes, acting more as a set of notes or reminders for a cook who already knew how to prepare a dish. Early recipes were generally for professional cooks many of these cookbooks; therefore, provide only limited sociological or culinary value, as they leave out significant sections of ancient cuisine such as peasant food, breads, and preparations such as vegetable dishes too simple to warrant a recipe.

By the 1800s, cooking had become a passion throughout the world. Using the latest technology and a new concept in publishing, Mrs Beeton published her famous 'Book of Household Management' in 24 monthly parts between 1857 and 1861. This paved the way for a new industry and by the mid 1900s there were literally thousands of cookery and recipe books available. The next revolution was that of the TV chef. Recipes accompanying television programmes were originally available by post from the BBC, and later on Ceephax or Teletext. Currently TV chefs such as Jamie Oliver and Nigella Lawson have prime time shows, backed up with websites containing additional information and recipes. Despite the rise of the internet, cookbooks remain as popular as ever, if not more so. What is their charm?

Why have recipes become more complicated? What we have seen in the progression of the recipe an opening up of its audience. Firstly for the most prolific professional cooks, then for professional cooks, then housewives, then everyone.

Types of cookbook

Recipe compilation – This group is focused around having many recipes in one book. It is common for the beginning or the end of the book to contain information on techniques and/or ingredients. Early incarnations of this type of book often had instruction on household management.

International/Ethnic cookbooks – These contain recipes, ingredients and techniques from a specific geographical area or culture. They often provide rich background and context and become as much a learning experience about the area/culture as about food. It is common for western cookbooks to group dishes by course; however it is more common for Japanese cookbooks to group recipes by techniques – e.g. fried food, steamed, grilled etc.

Professional cookbooks – Designed for professional chefs/students. Quantities of food are obviously larger than for home cooking and the books commonly deal with issues of hygiene and kitchen workflow. This group is closest in style to pre 19th Century cookbooks such as Apicus.

Single Subject Books – These deal with a specific ingredient, class of dishes or technique. They generally provide background information and history on the specific subject.

Celebrity Chef/Restaurant – These are often released in conjunction with a TV show. The majority of bestselling cookbooks fall into this category. A chef's personality will come through more in a TV show than in any other medium. People feel that they know the chef more. People prefer to cook recipes authored by people that they trust.

Special Diet/Ethical cookbooks – These provide ideas and recipes for those who can't or do not wish to eat a conventional diet. They often provide shopping tips and workarounds, as well as lifestyle advice.

Kids Cookbooks – These come in two main types - those containing recipes designed to be appealing for children to eat, and cookbooks designed to be used by children. This has been an interesting research subject for this report. Cookbooks for kids would usually be deemed impractical for adults. They generally contain few recipes and are heavily illustrated, designed to really engage children in the cooking process. A single recipe can span a large number of pages. The layout might be deemed non-functional by adult standards, but enriches the experience of cooking the meal. I found strong parallels here with many 'creative' adult cookbooks, such as *"In search of perfection"* by Heston Blumenthal and *"Les Diners de Gala"* by Salvador Dali. They both try to create an aura of fantasy surrounding the meal, so that the diner attaches more emotional significance to their food and ultimately enjoys the experience more.

Instructional – These are not cookbooks in the traditional sense, in that they are not focussed on recipes. They act as more of an instruction manual of how to cook, giving the user instruction of fundamental principles of food science such as flavour trails and heat chemistry. If used in parallel with recipes, books such as these can enable the reader to increase their culinary skills, leading to the ultimate goal of being able to cook without recipes. Recipe books teach more through experience and learning from mistakes, recipeless through theory and true understanding. Both of these are essential elements of being a great cook.

Empty/DIY – These are empty cookbooks, designed to encourage the user to write their own recipes in them. An example is the Moleskine Recipe Journal. They encourage sharing and creativity. It could be valuable to incorporate these functions into a device

Appendix 5 - Laser safety

Lasers can be dangerous. Even low powered lasers can cause damage to the retina or even blindness. More powerful lasers have the capacity to burn skin. Generally, the more powerful a laser of any given wavelength, the more dangerous it is. The wavelength of the laser affects the danger posed to the retina. Infra red lasers, as used in this project, are more dangerous than those in the visible spectrum because they do not cause an aversion response in the pupil (because the light is invisible). The lasers used in the LLP test model were 10mW 780nm. This is 'near IR'. This falls into the 'IR-A' category of optical radiation. IR-A has a smaller exposure threshold than visible light, meaning IR lasers must be lower power to be safe[68]. In addition, the kitchen environment has many objects which can reflect the laser into the eyes of users. Curved reflected surfaces such as wine glasses or spoons can converge the laser beam, making it more powerful at the retina. Because of these factors, it was essential that the device was a class 1 laser product. This means that it is safe in any circumstance, regardless of reflection. To achieve this, the laser power had to be reduced to safe levels. In the working model the laser diodes on their own were 10mW, class 3. In order to get clear blobs on the

camera, power was reduced by using a lens to diverge the beam over as large an angle as possible (120 degrees). This not only reduced the power at any given point in the plane, but also maximised coverage of the touch area. Also the lasers were set back from the front of the unit. Because the plane diverges the further away it is from the lens, it has less power at a given point. Setting the unit back therefore reduces the maximum possible power of the laser at the retina. Using data obtained from the laser diode manufacturers (see below), it was calculated that these techniques reduced maximum power to around 0.478mW at a distance of 1 inch. This was well within the safe limits as dictated by EN 60825-1 laser safety standards. Another technique to lower laser power was pulsing the laser in time with the framerate of the camera. This would be time consuming, and was not needed as class one had been achieved anyway.

EXPECTED POWER USING 30, 60, 90 AND 120 DEGREE LINE LENS AT VARIOUS DISTANCES FOR 25, 60 AND 100MW LASERS

POWER VERSUS DISTANCE				
25MW	1"	3"	6"	9"
30	9.56	2.88	1.44	0.2
60	4.78	1.44	0.72	0.1
90	2.39	0.72	0.36	0.05
120	1.195	0.36	0.18	0.025

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