FOOD MEDIA:

FOOD AND TECHNOLOGY AS A MEDIUM FOR

SOCIAL COMMUNICATION

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NATIONAL UNIVERSITY OF SINGAPORE

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SOCIAL COMMUNICATION

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Declaration

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.

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Acknowledgement

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Summary

Food is central in people's everyday life. Besides being a source of nutrition and energy, food is a crucial medium that bonds people together, for pleasurable communication and socialization. Some traditional styles of communication through food now may face potential disruptive technologies.

Prior literatures revealed limited investigations into the social significance of food when linked with digital technology. I proposed "Food Media" to signify food along with digital technologies as a social medium, where medium is considered for fostering impressive mutual experience beyond a channel for information transmission. This research looked into two approaches of combining food and technology to enrich communication and social interaction and demonstrated two cases, with the specific research questions being: 1) Can we enrich the co-dining experience between two remote parties by providing additional modalities other than visual and auditory channels? 2) Can food messaging service enabled by food printing be a viable and valuable messaging method? If yes, what are the uniqueness, values and limitations as compared with traditional messaging services, such as text messaging using a computing device or paper?

In the dissertation, I first analyzed the distinctive features and roles of food in interpersonal communication based on related literatures. I then provided a review of three related areas: traditional ways of food-mediated communication, digital technologies on cooking, eating food, and food printing, and research attempts to technologically mediate social experience around food, especially shared eating and food gifting. After that, I presented two cases of "food media" focusing on two types of communication, and studies surrounding them for further investigation.

One approach was applying technology to existing food activities. I developed the CoDine system to enrich food-based interactions in remote dinner context, which used interactive techniques applied upon physical dinnerware to reconstruct the missing multisensory experience of food in remote dining. It incorporates additional modalities like touch, smell and taste as well as food activities (food serving, tablecloth expression, and food teleportation) into remote co-dining experience.

By utilizing food's properties to enable an alternative messaging method, food messaging leverages food's sensory and emotional affordances to augment text messaging. It produces and delivers messages that can be literally consumed and more deeply felt by recipients than paper and digital forms of

messaging. My empirical studies suggested that food messaging combines elements of traditional food gifting and text messaging, making the communication experience multi-sensory and impressive.

There were three contributions: identification and characterization of food combined with technologies for interpersonal communication; two cases of "food media" (a novel system and a field study to further uncover viability and specialty of food as a social medium; and suggested implications for future research on food-mediated social experiences.

To sum up, this research has worked to enrich remote dining communication and text messaging beyond digital connection. It explored two different approaches to combine food and technology as a social medium, by emphasizing the communicative properties of food, and further demonstrated that the designed prototypes could add physical and multi-sensory experience to communication through user studies.

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Chapter 1

Introduction

1.1 Research Motivation

In the everyday household and community life, food is acquired, prepared, shared, and consumed multiple times every day, and it is often at the center of social communication, entertainment and cultural expression. Food is crucial to our survival and pervasive in our lives, as well as contributing to our sense of identity [57]. Besides providing nutrients and energy, food has many proven benefits in social communication.

Food always triggers comfort and happiness for both individuals and among groups. One important perception of food is the enjoyment of eating and socializing at the same time. People enjoy their food, relish the practice of making it, and above all celebrate the sharing of it [67]. More importantly, food gathers and ties people together, in its preparation and consumption [17,109]. Food is not only a common celebration symbol as treating others but also supports to establish new relationships between individuals. It is widely accepted that food is a necessity in successful social occasions, naturally

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gathering people around and serving as a topic of conversation. Not only do such practices improve the communication between all participants, but also make food actually tastes better, at least, in a psychological way, as the people involved enjoy the company of one another on a dimension that transcends the basic and sometimes mundane activity of cooking and eating.

The social roles of food can't be separated from the evolution of human communication. Social communication supported by or through food, defined as "food-mediated communication" here, takes many forms in everyday life, from the act of preparing, serving, consuming, and sharing of food, the appeal and symbolic meanings of food, to diverse food cultures. For example, consider chatting while preparing meals, leaving sweets on someone's table, sending a cake or chocolate over a distance, or even enjoying a meal together over video chat.

Additionally, besides paper-based communication such as letters and post-cards and popular electronic channels, food has been used occasionally in transmitting social messages. Examples include frosted words piped onto cakes with icing, letters carved into cookies, fortune cookie that hide a message inside, small candies with words for children, and food with printed logos for business promotion. For example, bean-paste pastries for Chinese

weddings are printed with the "double happiness" character, or with character

for "luck" for offering wishes. Figure 1.1 shows some examples.

Figure 1.1: Examples of existing "food-based messaging".

Food is mediating both synchronous and asynchronous communications, which may happen face-to face or over a distance. Food is also considered as a symbolic medium with internal emotional attachments to express rich meanings. Food is easily and commonly shared, and the offer of food is a simple way to demonstrate kindness and hospitality. Moreover, the symbolic meanings of food are widely used to deliver personalized messages (i.e., chocolate is often regarded as a symbol of love). Chocolate is culturally understood as a highly emotionally coded food that inspires feelings of self-indulgence and hedonistic ecstasy [109].

These traditional styles of communication based on food now face potential disruptive technologies. In the last century, a revolution in telecommunications has greatly altered communication by inventing new media for long-distance communication, giving birth to the "electronic media".

These emerging technologies allow information to circulate at a much greater speed over greater distances, and enable social communication through various formats of information, not only text, but also sound, image, and video, connecting people through computer-mediated channels.

In spite of the overwhelming advantages of "electronic media", it has been indicated that computer-mediated communication is a "cool" rather than an interpersonally or socially "warm" medium, which encouraged swift and efficient information exchange rather than facilitating interpersonal communication [94]. Most available technologies focus on transmitting explicit information, neglecting the emotional and subtle communication especially typical for intimate people [80]. Therefore, it is important to create new types of communication media that put more emphasis on the experience, particularly, the emotional perception, to highlight the expressional form of communication rather than informal.

On the other hand, in spite of the significant progress in the development of digital technologies on food, they were not driven to mediate social communication. Prior literatures revealed limited investigations into the social significance of food when linked with digital technology. And existing

research works mainly consider food as an output interface that may use flavors to represent different information or mechanically constructed objects.

Communication can be defined as "a symbolic, transactional process, or to put it more simply, as the process of creating and sharing meanings" [63]. The symbols in communication can come in a variety of forms such as verbal behavior, or words, and nonverbal behavior through facial expressions, eye contact, gesture, movement, body posture, appearance, and spatial distance [63]. In this dissertation, social communication is viewed as a process that enables interaction or exchange of verbal and nonverbal symbols between remote parties, involving shared activities, social message and expression.

Despite the growing prevalence of digital communication tools and sociological interest on food-mediated communication in everyday life, there has been a lack of studies into digital technologies along with food for interpersonal communication, especially in Human Computer Interaction (HCI). This research thus targets this problem by connecting theories of social science with innovative engineering implementation and empirical studies.

1.2 Research Statement

Existing communication tools are dominated by text-, auditory-, and vision-based methods. Although food's roles for interpersonal communication have been well recognized, it is actually not clear how technology could be combined to generate different communication experience. The social significance of food and the emergence of interactive media technologies inspired me to explore how these two can be merged to generate new types of communication, and how they can be different from current styles regarding communication experience.

What if food is introduced as a new media to improve communication experience between distributed people? I proposed "Food Media" to signify food combined with digital technology as a social medium. I defined medium more for fostering mutual experience beyond information transmission.

This research thus looked into two approaches of combining food and technology to enrich social communication and interaction through two cases, with the research questions being: 1) Can we enrich the co-dining experience between two remote parties by providing additional modalities other than visual and auditory channels? 2) Can food messaging service enabled by food printing be a viable and valuable messaging method? If yes, what are the

uniqueness, values and limitations as compared with traditional messaging services, such as text messaging using a computing device or paper?

Following the "Design-oriented Research", I explored "food media" through a designing and prototyping approach. This research had three objectives. The first was to identify key properties of food that could be utilized by technological intervention in mediated communication. Although the social significance of food has been well recognized, it was not clear which properties could be technological intervened to generate new ways of communication.

The second objective was to create novel methods for interpersonal communication with food. This research would look into two approaches that utilized the identified two properties and demonstrate two cases. For each, I would conduct the exploration in a fashion of an interactive process for designing everyday computational things, which makes up of four steps [151]: 1) Formulating objectives through theoretical review and analysis, 2) Design and implementation of a functional prototype, 3) User studies, 4) Analysis and reflection. New knowledge was gained throughout the four steps, contributing to the ultimate research goals.

The final objective was to further analyze the designed communication ways and reflect upon the uniqueness and affordances of food as a social medium to suggest implications for future research.

1.3 Research Contributions

The key novelty of this research is integrating food with technology as a social medium to enrich communication. Although previous works have proposed ways to mediate food socialization, they did not treat food as the center of communication, nor did they investigate the specific properties or values of food in mediating communication. This research has three contributions:

1) Identification and characterization of food combined with digital

   technology as a medium in social communication and interaction.

This research was concerned with innovation and characterization of "Food Media". It identified two properties of food that are potential for technological intervention in mediated communication, based on a comprehensive review of literature on food and media theories. On one hand, food-based activities have crucial roles in interpersonal communication; on the other hand, food affords rich social cues such as visual, touch, smell and taste, together with embodied symbolism that could trigger physical and emotional impacts on

communication. Although the notion of food as a communication medium is not completely new, the characterization and creative use of food along with digital technology for social communication is original in this dissertation.

2) Two approaches and corresponding cases that utilized such properties to mediate social communication and interaction

One approach was applying technology to existing food activities. A novel system called CoDine contributes the underlying software and hardware technology associated with remote co-dining experience. CoDine incorporates additional modalities like touch, smell and taste, and food activities (food serving, tablecloth expression, and food teleportation) into remote co-dining experience, preserving the ritual activity like food serving and also creating new channels like tablecloth expression and food teleportation, beyond video chatting (Figure 1.2). It is through these physical interactions that people engage themselves into the shared dining experience with feeling of "being together". As a result, participants found additional engaging elements that are not presented in current remote co-dining systems.

By utilizing food's properties to enable an alternative messaging method, food messaging leverages food's sensory and emotional affordances to augment

text messaging. It produces and delivers messages that can be literally consumed and more deeply felt by recipients than paper and digital forms of messaging. Figure 1.3 demonstrates a future scenario. With its unique properties of being sensory, symbolic and emotional, food as a message carrier could positively reshape the existing social messaging practice.
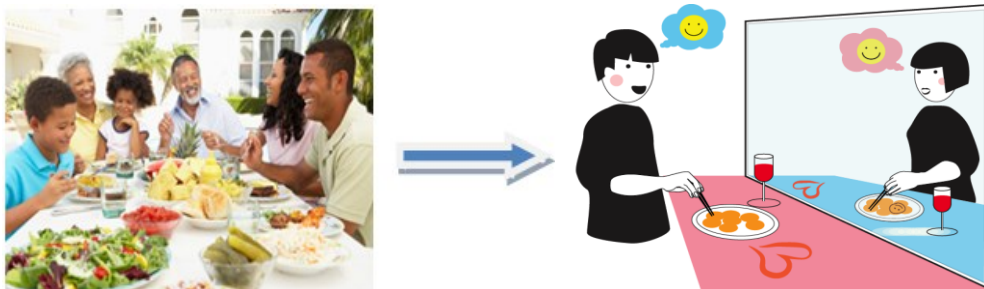
Figure 1.2: CoDine system scenario – mediated dining communication for remote individuals.
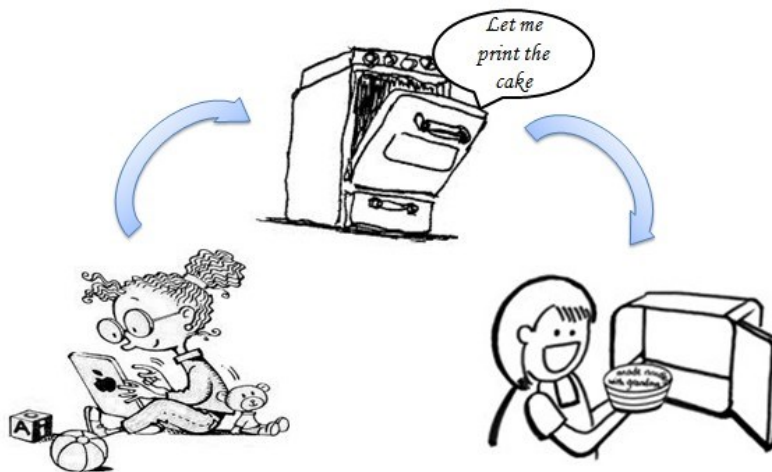
Figure 1.3: Scenarios of *Foodie*: remote messaging via food.

Furthermore, this research demonstrated the viability and specialty of food messaging based on rich empirical data and analysis. The results of exploratory interview with 12 potential users and a field study involving 768

users demonstrated people's strong acceptance and perception of food messaging and identified its scenarios of use. Additionally, empirical data uncovered the different behaviors between genders in using food messaging. Further discussion identified the fundamental and distinctive properties of food as a messaging medium and suggested its appropriate niche among mainstream communication media. Participants considered it combined elements of traditional food gifting and text messaging, making the communication experience multi-sensory and impressive.

3) Insights and implications for future research on combining technology and food to enrich social communication and interaction.

As discussed in this research, food has both benefits and risks in communication and preferred scenarios of use (e.g. females, intimate people, hedonic atmosphere), which needs to be considered carefully when choosing the appropriate context. Generally, technology could maintain and add new sensory interactions to traditional food activities, and food could also be technologically enhanced to preserve and add new senses to existing communication. For both approaches, it is important to carefully consider how to make better use of food's social roles and properties with technologies to complement targeted communication practices, rather than task efficacy.

This dissertation is useful or might be of interest to researchers, designers, and developers in the fields of:

- Intersection of food and social communication

- Interactive technologies around food and practices

- Food and Human Computer Interaction (HCI)

1.4 Thesis Overview

This research explored the potentials of food and digital technologies to provide enriched experience rather than task efficiency [98]. The goal was to combine food and technology in different ways to generate new types of social communication and interaction.

I first reviewed relevant theories on remote social communication and experience medium, together with literatures on social significance of food, to identify key properties of food for technological intervention in mediated communication. I then applied two approaches that utilized such properties to mediate communication and social interaction: applying technology to existing food activities, and applying food to existing technological communication practice. It demonstrated two corresponding cases of "food media" (defined as food along with digital technologies as a social medium): enhancing food-

based interaction using CoDine, and enabling a richer alternative communication method called food messaging. Following that, I conducted a series of empirical studies to further discuss how food and technologies could enrich communication in specific cases.

This research is a combination of 1) exploration into food, 2) interaction design, 3) ubiquitous computing and 4) experience-oriented communication (Figure 1.4).
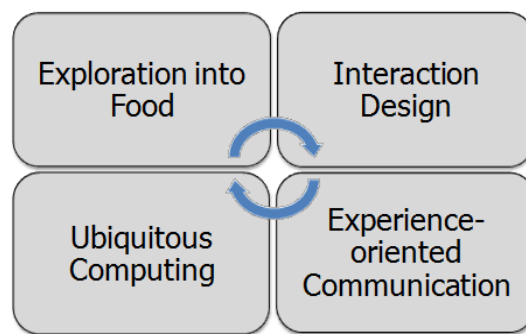
Figure 1.4: The four components of the dissertation.

Designing interactive systems utilizing food needs a thorough understanding of "why use food and how food can be digitally-enhanced within a social context" at first. In this dissertation, the discussion into food from different perspectives can provide connected information about people's everyday routines, coordinative practices, and personal attachments with food. Such an understanding can inform its unique properties and affordances as a social

medium, and more importantly, potential design space of how technologies can be integrated accordingly.

The second component, interaction design, refers to explore the ways in which people can interact with each other enabled by food or its accessories. As defined, interaction design is "designing interactive products to support the way people communicate and interact in their everyday lives" [156].

The third component, ubiquitous computing, conveys a technology push that goes beyond the traditional desktop metaphors. Defined by Weiser, Ubiquitous Computing is the method of enhancing computer use by making them available throughout the physical environment. As he indicated, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" [168]. Following this notion, this research has been exploring ways that embed computing technologies into everyday objects and practices.

The fourth component, experience-oriented communication, delves into designing computing technologies to provide appealing social experiences. Since the late 90s, a growing body of work [23,79,116,128,142] within HCI has attempted to shift the focus from the task-based or functionalist viewpoints

to a more holistic view on how users experience technologies. Following this, my research focus is not only on building connections or exchanging information, but how people experience a technologically enhanced medium, taking emotional, pleasurable, playful and other ineffable aspects into account. People react emotionally to experience probably because they feel actively involved, which indicates the necessity to incorporate people's activities to communication process when designing towards experience-oriented communication.

The dissertation is organized as below. Chapter 2 introduces theoretical concepts and analysis in related domains; Chapter 3 presents a comprehensive review of computer-mediated communication, traditional food-mediated communication, emerging technologies of food, as well as research attempts to mediate food-based communication and socialization. Chapter 4 introduces methodology and theoretical framework of this research. Chapter 5 and Chapter 6 cover the detailed design, implementation, evaluation, and analysis of developed prototypes that demonstrated two cases of "food media". Chapter 7 reports a field study of food messaging in real social environment. The empirical results demonstrate the applicability of food media, which consolidate the laboratory findings, and reveal more dimensions of food media.

Chapter 8 constructs a set of implications and guidelines for researchers and consumers, drawn from the developments and experimental studies. Finally, chapter 9 concludes by highlighting the contributions and how this research can boost future exploration towards new types of communication that are warm, engaging, and emotional.

Chapter 2

Conceptual Foundations

In recent years, communication media types have expanded, and communication patterns have changed as new technologies are being developed. This research focused on food as media in social context for non-co-located people. In this chapter, I provided theoretical review and analysis from four aspects: I began with mediated communication and communication medium in remote situation, and highlighted my focus on experience-oriented communication; I then took a holistic review of food, in terms of its properties, functions, practices, especially its current roles in communication, mentioned as "food-mediated communication".

2.1 Social Communication and Interaction

People always have a strong desire to communicate with others, especially in the current society when a growing number of people are distributed globally thus are away from their families and friends.

Recent technological developments have enabled people to communicate in previously unimaginable ways. One compelling example is advent of the

Internet, which has enabled physically separate individuals to stay in "electronic proximity" [44]. It is widely accepted that communication technologies are not replacing face-to-face interactions, but are definitely influencing the ways people communicate. Most of the social communication technologies have relied on audio-based, text-based and graphics-based means to transmit information in digital format.

2.1.1 Mediated Communication

Communication utilizing technology is referred to as "mediated communication." The current digital age is distinguished by rapid transformations in many kinds of technological mediation through which we encounter one another. The fundamental purpose of communication technologies has been allowing people to exchange messages without being physically co-present [16].

Mediated interpersonal communication is currently one of the most dynamic areas in communication studies, reflecting how individuals are utilizing technology more and more often in their personal interactions [94]. A large body of research has accumulated on "Computer-Mediated Communication (CMC)," - defined as "any communication patterns mediated by a computer" [118]. CMC allows geographically separated individuals to interact verbally

and nonverbally in a shared virtual space in real time. The main features of these new media are that they allow people to exchange short and long messages in their small communities to inform others about their daily activities in an interactive way.

Basically, a communication process can occur on an instantaneous or a delayed basis, categorized into synchronous and asynchronous communication. Communication with perceptible delays is typically referred to as asynchronous (such as email, letter), while those with immediate (or nearly so) information exchange are called synchronous, such as individual/group face-to-face conversation, telephone, videoconferencing, instant messaging, etc.

To enhance interpersonal communication in a shared virtual space, Transformed Social Interaction theory (TSI) explores how CMC allows people to interact in ways not possible when face-to-face, involving novel techniques that may change the nature of social interaction [10]. Interactants could selectively filter and augment the appearance, verbal and nonverbal behavior of their avatars, such as the facial expression, gaze, and speech [9]. By augmenting their representational, sensory, and situational characteristics, interactants may be able to achieve levels of interaction that actually surpass face-to-face interaction. Although this theory is mainly applied in

collaborative virtual environments (CVEs), it is informative for my design of mediated communication that involves changing people's interactions in physical space.

Characterized by programmed interactivity and convenience, this emergent form of social communication is playing an increasingly prominent role in today's computerized society. Although technological developments have made it easier than ever to contact people, the information-focused connection has also removed the human elements from communication, which would cause the feeling that the sender has distanced himself from the recipient.

2.1.2 Experience-oriented Communication

New technologies and new modes of communication are constantly coming into use. But communication is more than information exchange; it is rather a process embracing social experience. One of the most important goals of communication is to strengthen relationships by establishing emotional ties through exchanging personal experiences. But recent technologies do not explicitly consider emotional, expressive nonverbal information as a main purpose of a communication act [80].

Human communication is often classified as either instrumental or consummatory [46]. The purpose of instrumental communication is to change receiver's cognition and/or action by communication, such as providing knowledge to others, and changing other's actions. The purpose of consummatory communication, rather, is to share one's experiences and emotions [61]. Although exchanging information is one of the most vital functions of communication, it alone can't be taken as the whole communication. Experience-oriented communication has been raised in the literature of social communication.

Feeling communication, for example, focuses on emotional communication that can deeply send our feelings and emotions to others. In other words, feeling communication does not only convey raw data or information, but also our deep feelings, intentions, expressions and culture [31]. Similarly, Tsunagari communication aims at "fostering a feeling of connection between people living away and maintaining their social relationships" [87]. On the other hand, humans communicate and interact with each other in rich and complex ways. Thanks to the increasing use and release of new communication devices, multimodal communication looks into the utilization and combination of multiple interaction modalities to seek for increased

efficiency and more emulated experience of direct face-to-face "natural" communication. All these terms highlight either the situated context or emotional feeling beyond the informal form of communication.

Defined by J. Ornbo, experience-based communication is "the conscious utilization of physical meetings and locations as a means to build relationships and become significant to a given target group" [131]. They raised this concept and proposed EET model based on years of studies on communication experience to illustrate this type of communication: Experience (physical space), Engage (mental space), and Transform (social space) [131]. Physical experiences are what we see, hear, feel, smell, taste and sense. Mental experiences are when we begin to feel involved. Social experiences are when the experience and involvement lead to empathy, interaction and communities [131]. Inspired by this concept, I consider designing interactive systems would involve not only the communication process, but also the environmental and associated setting to enrich the experience, and take people's engagement into consideration.

2.2 Communication Medium

As discussed, media technology has made it increasingly easier to connect diverse people from far and near geographical locations. People rely on

different types of media to build the connection when face-to-face is not available.

2.2.1 Definition of Medium

In literatures, "communication medium" is defined as a delivery mechanism or channel for messages to a receiver or audience [159]. In order to understand the interactive media better, it is useful to take a look at the evolution of media in a broader context. In ancient times, communication in human societies was limited to spoken words and only millennia later did the invention of writing and printing extend communication a little beyond the restrictions of time and space. The Industrial Revolution brought the telegraph and telephones into society, and emails, instant messaging, and social network services have emerged as significant tools to connect people. These new media further "extended society beyond the physical links between individuals" [47].

Researchers have defined the term "medium" in many ways. As Ornbo et al. indicated, "Anything that can carry a message can be considered a medium, which is exactly as it should be" [131, p79]. J. M. Gutteling defined, "the communication medium refers to the channel with which the information reaches the receiver, visually or by auditory organs, verbally or nonverbally, through an actually present source or transmitted electronically, etc" [70]. On

the other hand, N. Postman mentioned, while "a technology … is merely a machine," it "becomes a medium as it employs a symbolic code, as it finds its place in a particular social setting". Thus, "a medium is the social and intellectual environment a machine creates" [94,146]. In this sense, a medium is a system. It's not just an object, but rather a way of thinking, expressing, and experiencing: every social reaction, feeling, and sense of information we get occurred during communication as a whole is a medium.

Researchers have mainly looked into these two types of communication media.

1) Print Media:

They include all forms of printed communication such as letters, cards and notes. Although print media may rely on technology in its production, consuming print media does not require technology. Print media are easily replicated and can be efficiently distributed to others. Invention of the printing press led to an expansion of written communication.

2) *Electronic Media*:

Beginning use of electricity expanded the range of communicative options and the communicative capacity by further reducing physical barriers for communication. The more recent types that involve computer and the Internet

are also referred to as *Digital Media*. People use electronic devices to access electronic media such as emails, instant messages, short messages, and telephone conversations. Various forms of print media, verbal and nonverbal communication have been adapted to electronic media. For example, video chats with friends and signal facial expressions through emoticons.

Since all types of communication technologies have their specific functionalities and appropriateness within certain context [152], it does not make sense to think of one technology as a full substitute for another, or to regard one as being generally superior to others. Rather, they all support communication, but in different ways. The fact remains, however, that the very nature of communication changes when it is mediated by technologies. Critics see mediated communication as impersonal, artificial, or even hostile. It has been said that they lack many aspects of traditional communication such as physical presence, social, nonverbal, and contextual cues [6, p347], which motivates me to pursue media types that can bridge this gap.

2.2.2 Experience Medium

Previous communication channels seem to overlook the importance of experiences and the advantages of involving the senses in communication. Study has shown that the telephone and the widely available video

conferencing systems are built with functionality in mind (i.e., transmitting voice and video), not with the feeling and experience to provide [80].

In response to what have been discussed about experience-oriented communication, I examined current media from the characteristics associated with experience, to illustrate the features of experience-oriented medium. I now discuss the primary theories that have been widely used to measure and distinguish the experience of different communication media. Since experience may vary according to different properties of the medium, like what are perceived, and what feelings are triggered, I included Media Richness Theory, Affordance, and Multimodality to illustrate the nature of communication media. I then discussed Social Presence since it's an important measure in evaluating mediated remote communication experience. These theories emphasize how media differ in the extent to which they can (a) overcome various communication constraints of time, permanence, distribution, and distance; (b) convey equivocal information; and (c) transmit the social, symbolic, and nonverbal cues of human communication.

Media Richness, Affordance, and Multimodality

In their pioneering work, Richard L. Daft and Robert H. Lengel proposed Media Richness Theory in 1984, which was a framework to describe a

communication medium by its ability to reproduce the information sent over it

[42]. Media richness represents the extent to which media are able to bridge

different frames of references, make issues less ambiguous, the number of

cues and sense involved, personalization, and language variety [81]. For

example, a letter can't reproduce audio cues such as voice, so it is a less rich

medium than telephone; nor can it reproduce visual cues such as facial

expression, thus less rich than video conferencing. A similar concept is

modality, known as the channel to transmit signs. It is the communication

equivalent of what psychologists refer to as "codes," and has generally been

assumed to refer to the types of channels that are present in a communication

scenario (e.g., text, audio, text + audio, etc.) [94]. Artifacts may not afford

enough intuitive features to be understood easily, so as messages. Adding

extra modality can enhance people's perception of information. In other words,

the more modalities a communication medium has, the richer it is.

Multimodality is the use of several modes/channels to support the interaction.

Media Richness Theory was originally used to facilitate the selection of a right

medium for particular task within an organization to decrease the ambiguity

and enhance the efficiency of information exchange. It was argued that task

performance would be improved when the richness of media matched with the

task equivocality. The more equivocal a message is, the richer medium should be selected for the receiver to decode. An understanding of this theory is helpful for examining the different capabilities of communication media.

Affordance could be another element offered by technology that influences medium's capability to enhance communication. As Norman writes, "The term *affordance* refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could be used..." [129]. It is dependent on the users' knowledge, culture, past experiences and memories. This definition suggests that, perceived affordance represents user's perception of a communication medium about how it may be used for interaction. It can act as a moderating construct of people's media use. This concept could help to further understand people's adaptive patterns to adopt different media for specific communication purposes.

As acknowledged, the fundamental characteristic of all mediated interactions is mediation, or interacting with spaces and people that are not immediately present in our physical environment [43]. In relate to experience medium, I believe higher richness would afford more social cues, and positively influences the experience sharing over the media. One of the strengths of experience medium is that it combines multi-sensations with physicality.

Incorporating multiple social cues would allow the transmission of multi-dimensional information, more importantly, feelings and contextual environment as well, either physical or psychological.

Researchers have also proposed that media choices have symbolic meanings in social settings [163]. Symbolic meaning of a medium is a socially based influence that is important for media choice and for attitude towards it. Previous research has found that media are used to send symbolic messages above and beyond explicit message content, and that communicators are aware of these messages [164]. To the extent that individuals are conscious of these symbolic meanings, I expect their media choices are associated with the symbolic meanings carried by the choice of a particular medium [164]. In this view, the medium becomes an important part of the message [117], and the medium's symbolic meaning can contribute to the communication as well.

Social Presence

Presence normally means "being there"; the concept of social presence, i.e. the sense of being together, is the degree to which a medium is perceived as conveying the presence of the communicating participants [157]. Social presence is further expanded to classify three themes of 1) co-presence, or a mutual awareness of others and others ware of self; 2) the experience of

psychological involvement of responding to the emotional states of others; and

3) behavioral interactions that are believed to be responsive to others [74].

The feeling of social presence depends not only on words conveyed through the communication medium, but also the medium richness, i.e., the amount of verbal and nonverbal cues involved in the communication context. Accordingly, face-to-face communication is more capable to provide social presence, while media such as computer-based communication and written format are considered as lower in social presence due to the lack of nonverbal elements most of the time.

Particularly for mediated communication, defined as "a sense of being with another in a mediated environment", social presence is the "moment-to-moment awareness of co-presence of a mediated body and the sense of accessibility of the other being's psychological, emotional, and intentional states" [21]. When face-to-face is not available, we sense and interact with others not with their immediate embodiments of minds, i.e., physical bodies with their actual faces and voices, but with mediated embodiments of minds, representations made of pixels, ink, paper, etc. In this respect, media that better capture the interactive and perceptual properties of remote others, and

that enable mutual feedback may evoke stronger social presence than just a text SMS from another.

It is important and desirable for individuals to have an increased sense of social presence in experience-oriented communication, experiencing the others "as if they were co-present and socially engaged" with others [21]. Different from designs that applied social presence for awareness, I am more driven by the social needs of communication and maintaining relationships. The degree of social presence has significant impacts on people's perception, appreciation, participation, and level of satisfaction in remote communication activities.

Both media richness theory and social presence theory are based on the premise that media have different capacities to carry interpersonal communicative cues [82]. They provide a theoretical basis for technology-mediated communication, in particular, how different technological forms and mediated embodiments of the other influence the process and mental representations in remote social interaction. Richer media are primarily considered to enable the transmission and display of increased nonverbal social cues, thereby more likely to support affective communication in personal relationships. Depending on the properties of medium, nature of interaction, and individual differences, different media enable people to

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experience varied levels of social presence, be it fleeting and superficial or strong enough to elicit powerful emotional reactions [21].

Based on these theories, I considered experience medium should be richer with multimodal interactions, providing enhanced sense of social presence, and symbolic meanings afforded by the medium. In other words, for experience-oriented communication, information content is of secondary importance to the emotional, relational content transmitted through the medium. Experience-based communication creates resonance internally and externally [131].

2.2.3 Summary

The merger of traditional and new media creates a global social sphere that is changing the ways we communicate with others. The development of new communication technologies and the creation of activities in which these technologies are being used make it important to examine the ways different media impact the quality or nature of communications. It can be summarized that existing communication media differ from each other in various aspects, and they are selected for different purposes under different social contexts. As Postman mentioned, "the forms of media regulate and even dictate what kind of content the form of a given medium can carry" [146]. Most recent

technologies aim at efficiency of communication; I took an alternative path that is more experience-oriented. In this research, I would embrace multimodal interactions and multi-sensory experience into people's routine activities, to enhance social presence beyond verbal or visual communication. Complementary to this approach is the appreciation and utilization of considerable potentials of designed media to provide features typically unavailable in current communication.

2.3 Food

Food sustains life, but the importance of food for human beings, as widely acknowledged, is never nutrition alone. The topic of food can serve as a theme that ties individual actions to wider social, cultural, and technological issues. Unpacking the complexities of food requires a large amount of analytical effort and empirical investigation. In this section, I took a holistic view into different perspectives of food, and then focused on its social components to detail its core connection with communication, including social activities and its potential properties that can contribute to enriched social communication.

2.3.1 Properties of Food

The topic of food is widespread over the world and popular in various research domains, the study of food has mainly been the sphere of anthropologist,

historians, economists, sociologists, psychologist, cultural scholars, nutritionists, and culinary professionals. Food is a central part of human life, beyond feeding people with energy and nutrition; it is also symbolically interwoven with human society, art, media, entertainment, and culture as well. With the advancement of computing and network technologies, food has also turned to be attractive for HCI researchers. Furthermore, food is becoming a theme of particular fascination in digital games, e.g. Cooking Mama, Fruit Ninja, Cooking Dash, using computer-generated graphics and animations to simulate food cooking, selling or eating activities in virtual environments.

Food has multiple sensational dimensions, involving not only visual, but also tactile, smell and taste feelings. Food is distinctive for its organic nature, with properties related with human senses, such as texture, color, smell, taste, temperature, acidity, moisture and appearance. Besides, it also contains other characteristics like conductivity, quantity, quality, variety, size, weight, shape, structure, calories, nutrition, convenience and description. The rich features make it potential to be digitally enhanced and adopted in different domains.

On the other hand, due to the ubiquity of food, computing technologies have also been used to achieve different functions around food, such as nutrition awareness, social sharing of recipes and digital games, which gave birth to the

"virtual food". Contrary to real food, I defined "virtual food" as the "digital representation of food". Examples include pictures of real food on social network sites, animated food in video games, etc.

Both types of food have properties that can be represented visually, like shape, color and texture. Using vision technologies like real-time tracking and recognition, and augmented reality, virtual food sometimes present more layers of information than physical food, for example the detailed nutrition data, comparison with other similar food, and customized recommendation [60], but features related to human senses other than vision could be difficult to be virtually reproduced as the original sensations.

2.3.2 Functions of Food

Food is pervasive, touching our life in every conceivable way. Biologically, humans need food to survive and get energy. Beyond that, food consuming is also in the fabric of people's everyday life, and is charged with intense and complex relationship with people's emotional feelings.

In this dissertation, based on the literatures that described the social, cultural and emotional functions of food, I categorized food's functions into three main groups: biological, psychological and cultural, from individual to social level.

But these functions are not mutually exclusive; they are interrelated with each other in different manners. Each function can be extended to different levels, shown in Figure 2.1. For the psychological function, the emotional feeling can be derived from food itself, or during the food-related activities (Figure 2.2). Derived from social interactions, these functions operate at individual, conscious level as well as at more pervasive, cultural and subconscious levels.
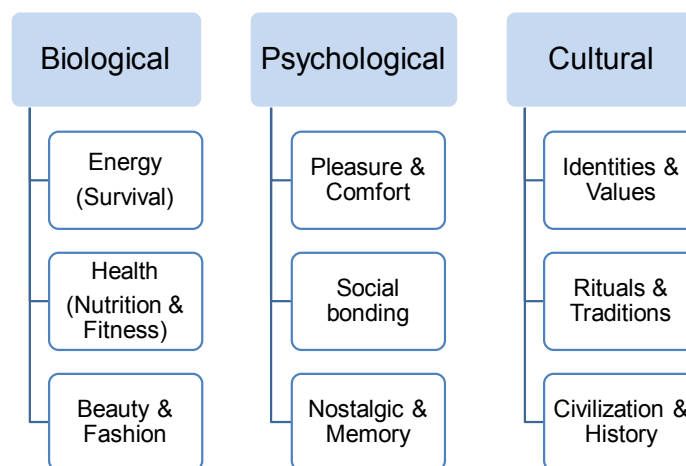
Figure 2.1: Main functions of food.
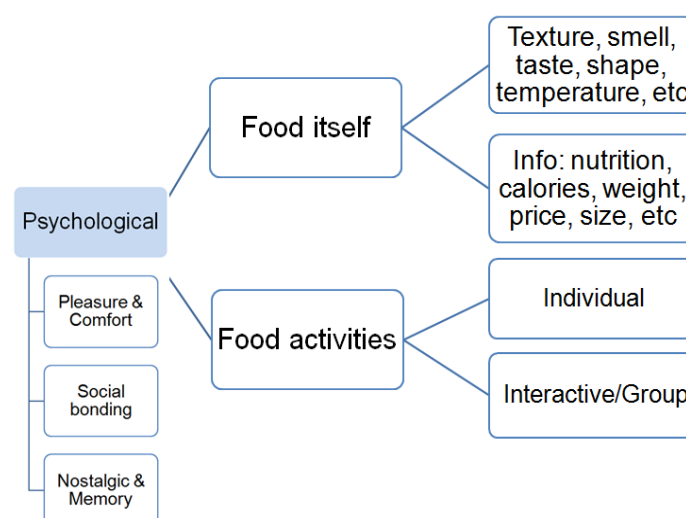
Figure 2.2: Composition for psychological function of food.

One main function of food is the psychological effect. First, food and related activities provide pleasure and comfort, individually and socially. There is a strong link between the taste and smell sensations and the emotional dimensions of human experience [109]. For many, pleasures gained from food are the high points of their everyday sensual experience. Food can alleviate depression and provide comfort, and it is always considered as optimum for premium luxury, rewards, and retreat.

Socially, cooking and eating together are always compelling experience, they create a warm atmosphere that keeps people happy, occupied, and entertained. As Finkelstein proposed, "The idea of food as a source of amusement has been parallel to the experience of eating since gastronomy began" [56]. People always use food as a gift for special expressions and greetings. Food is often a purchased commodity gift, particularly sweet foods such as boxes of chocolate and preserved fruits. People offer and share food to show hospitality as well, binding communities together [34]. In addition, people experience different emotions in response to food. Due to these subtle associations, people use food to express, suppress, and deal with various emotions.

Thirdly, food is reputed to have a direct effect on emotions and memory, triggering nostalgic feelings related to previous memories. There is also a

strong link between memory and the emotional aspects of food. Food choices are associated with these memories, providing comfort by evoking feelings connected to relationships with special others.

What's more, food acts as an embodiment of emotional expressions and a bearer of cultural heritage. Special foods or significant eating events are often imbued with core social values [148]. In accordance with the "Slow Food[1]" philosophy that focuses on the pleasures of table, dining table represents the material culture of kitchens and food, and serves as a metaphor for shared community. For Slow Food proponents, the pleasure of table is seen as a key element in cultural reproduction [140]. Food has also been used as a metaphor to represent individual identity, which could separate and distinguish groups from one another. As Charles indicated, "So closely linked with social relations are food and eating which actually signify identity" [29]. The nostalgic longing and consumption of particular food items sustain one's sense of cultural, familial and self-identity. Most of us would admit that, "One way of exploring a culture is through their food and cultural food practices".

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[1] *Slow Food International* is a non-profit group focusing on preservation of the cultural, culinary, and artistic local traditions (http://www.slowfood.com/).

Food stirs emotions, because of its sensual properties and social meanings. In sum, food is "something we use to define ourselves" and food's "powerful social, economic, political and symbolic roles cannot be ignored" [18].

2.3.3 Food-related Activities

Food is not standalone but associated with a series of daily activities. The pool of food activities encapsulates the broad spectrum from planting to serving food, which occurs across work, home, and leisure spaces.

Most food activities take place on social level, centered on gathering, preparing and eating food, from simple family meals to great occasions like celebration and commemoration. A meal eaten alone can be an awkward experience, while the coupling of meals and social interactions is a natural pairing. When eating is performed in social interaction with others; meanings attached to food, eating and meals are rooted in subconscious associations that result from those interactions [66]. Sharing food has almost magical properties in its ability to turn self-seeking individuals into a collaborative group [18], according to the concept of commensality. In a word, various forms of social communication take place in performing food activities, through which people build and enhance social connections.

2.4 Communicative Components of Food

As discussed above, food is multi-facet and multi-functional. For the focus of this research, I detailed the communicative components of food, in terms of the social, symbolic, and emotional associations. It is difficult to imagine a social occasion where food is not present. When meeting friends or entertaining guests, people typically extend friendship and hospitality through food. The presence of food creates an atmosphere of generosity and familiarity; it establishes a bond and facilitates interaction among people [113]. In the act of eating, people make connections with the outside world. "A powerful mode of mediation", Elspeth Probyn argues, "joins us with others" [147]. Similarly, Peter Farb and George Armelagos held the view that eating functions as "the primary way of initiating and maintaining human relationships", they emphasize that to a large extent, food "is what holds a society together" [55].

I believe food is one of the best and most enjoyable social communication platforms – individuals interact through and around it. Food is the glue that bonds people to their family, friends and neighborhoods, on occasions like family dinner and parties. In some cases, eating becomes a substitute for these missing key relationships. Since meals are one source of communal activity, being deprived of this way to connect with others heightened the sense of

isolation they felt [66]. Pleasure and family connectedness are included among

the several positive aspects of people's interaction with food [67].

2.4.1 Symbolism of Food in Communication

Food can convey meanings beyond itself in communication, it is an excellent

lens through which we can appreciate the universal need for nourishment and

find diverse expressions in food's cultural messages and uses.

Food is poised between the 'natural' and the 'cultural' worlds, in which it is

simultaneously a material-physical entity, a product of human activity, and a

very powerful carrier and reservoir of symbols [83]. People assign to foods

meanings that reflect characteristics salient within the physical, social and

cultural settings they inhabit. For example, some foods have an embedded

romantic connotation: most people think of champagne, strawberries and

oysters as amorous foods, and consider them as romantic or intimate. People's

ideas about food are affected by the cultural and regional differences in food

customs, the norms of culture they belong to, as well as the symbolic and

associative meanings of food [62].

The cultural character is one main source of symbolic meanings, which have

been highlighted by theorists as a highly symbolic realm subject to discourse

and interpretation. Roland Barthes considered food to be "a sign" which presents and signifies "an entire world" (social environment). Food, therefore, is "a system of communication, a body of images, a protocol of usages, situations, and behavior" [12]. Echoing this, Mary Douglas regarded food as a code conveying messages expressive of social relations of "hierarchy, inclusion, and exclusion, boundaries and transactions across the boundaries". People, for example, share meals with family and friends, but probably only have drinks with acquaintances. The difference between sharing of meals and drinks indicates "the line between intimacy and distance" [48]. Similarly, Carole M. Counihan saw food as a language: "In every culture, foodways constitute an organized system, a language that – through its structure and components – conveys meaning and contributes to the organization of the natural and social world" [38]. Whether as a sign, a code, or a language, food offers significations beyond its survival function, revealing people's social connections with the outer world.

Although this character is rarely questioned, the potential of a semiotic approach to mediate communication was still quite untapped. Semiotics, with its focus on signification and communication processes, can offer analytical

tools to analyze how food can be perceived and interpreted to different social meanings.

I can analyze the communicative aspect of food at the lower level of how food can stand for something other than itself. This study of signs – *semiotics* – has previously been explored in the literature in the context of food [48]. In this work, food is described as a kind of social code that affords possibilities for sending particular messages: "If food is treated as a code, the messages it encodes will be found in the pattern of social relations being expressed".

In the semiotics of Peirce, food (or any object) can stand for something else in three ways, which collectively support the communicative practice of creating, managing, and sharing meanings with others [101]. Consider the example of toast decorated with chocolate in the shape of the Eiffel Tower. First, food can act as an icon signifying through similarity of quality, so it could signify chocolate or the Eiffel Tower itself. Second, food can act as an index signifying through physical or experiential relationships, so it could signify the time the creator and recipient visited the Eiffel Tower. Third, food can act as a symbol that signifies through convention, so it could signify love through the pleasurable associations of chocolate and the romantic associations of the Eiffel tower. In practice, signs are often a combination of the three forms. I am

interested in how food-mediated communication can provide value through each kind of sign, especially the extent to which the ingredients themselves have common symbolic associations.

2.4.2 Distinguished Attributes of Food as a Social Medium

The previous sections have proposed some reflections towards a more far-reaching analysis of food; particularly suggest its heuristic value as a social medium for enriched communication experience. I can summarize that food is a primeval common communication medium that has its own language of expressing messages to others.

First of all, the analysis of food through the lens of contemporary social, cultural and semiotic aspects can help focus on the distinguished properties of food as a social medium. A semiotic analysis can also help to achieve a more nuanced and holistic interpretation of food-mediated communication, a process that involves not only verbal words, but also the whole embodied experience.

As such, food has gained wide attention transforming its traditional roles to a more expressive, interactive medium. Food, of course, has a supremely physical presence, and we interact with this presence through our senses: we

smell, taste, see and touch food, and sometimes hear it (e.g. the sizzling of frying food) [109], indicating its potential to achieve enhanced sense of presence as a kind of physical media. Moreover, people are familiar with food, and food in itself encompasses a variety of characteristics that can be utilized to communicate expressional and emotional feelings, such as texture, shape, pattern, color, even smell and taste. For example, the aroma of baked bread, fresh coffee, and the sensation of chocolate melting in the mouth, can often evoke a sense of comfort and contribute to the pleasurable experience. Such a perspective is primarily concerned with modality as an affordance that results in certain communicative processes and outcomes, but not as an independent technological artifact in and of itself [94]. As mentioned earlier, all the social cues are important to interpreting messages and creating a social context within which messages are meaningful.

In addition to cultural and social associations, food is also characterized by powerful emotions [108]. Previous study findings revealed that a wide range of emotions are associated with food, including anger, anxiety caring, embarrassment, frustration, guilt, happiness, hate, love, nostalgia, resentment, security and comfort.

Edible, symbolic, and emotional, food can be a media type that "extends new possibilities for expression, communication and interaction in everyday life" [114]. Food is both a source of signification and an effective form of communication, based on a wide variety of edible substances, practices, beliefs, and norms that form a network of interconnected systems [133]. The core concept of *Food Media* is to create ways for social communication with interactive and emotional experience supported by food and technology.

2.5 Summery

Remote communication takes various forms through CMC media. I do not see these digital media as the end of meaningful messaging and personally valuable forms of communication. Rather, I see an exciting opportunity to look at what food can provide and leverage on these qualities to support the current media with expressive and valuable communication experience.

This chapter covers the topics of remote communication, communication medium and food, to provide theoretic background for the whole research. I highlighted the focus on "consummatory communication" rather than information or efficiency, and identified the potential attributes of food in mediating social communication. Specifically, I believed the interactive activities exclusive to food and multimodality, represented by symbolic and

emotional attachments, could be better utilized by digital technologies to enhance communication.

The holistic reviews suggested that food has strong potentials to be digitally enhanced as a social medium, transforming communication to more experience-oriented. Food involves a variety of interactive activities, from preparing, cooking, and eating food, which could be technologically intervened to highlight the social experience. On the other hand, being organic, food is embedded with rich sensory properties that can convey social cues when face-to-face communication is not available. In other words, food is multimodal; it may generate richer communication channels than existing media that mainly rely on audio and vision. Food could afford enhanced communication varieties based on its physical and psychological properties, verbal or nonverbal, expressive or implicit, which would trigger more values appreciated by people.

To sum up, the particular properties of food make it promising as a social medium, which can be intervened by digital technology to enable remote social communication in an engaging and interactive way.

Chapter 3

Literature Review

This chapter first overviews current approaches for mediated communication, computer-supported co-experience and food within HCI domain to reflect the underexplored adoption of food under the scope of CMC, followed by research works into existing communication mediated by food, and then presents a detailed review on relevant digital technologies along with food, and research attempts to mediate the social experience involving food, e.g. shared eating. I made comparison between this research and those in the literature review to highlight the research significance.

3.1 Communication and Mediated Co-experience

The variety of Internet-based communication systems keeps growing, targeting both synchronous and asynchronous communication that may occur collocated or remotely. When face-to-face (FtF), collocated people normally rely on all the human senses in synchronous communication, considered as the richest media [43]. The media would become less rich when communication is asynchronous. For example, people may leave a message on a note, in

telephone, or record a video clip to be received by someone else later, which probably involves only one or two modalities. On the other hand, media technology is enabling and changing how individuals interact over a distance. A growing number of synchronous and asynchronous communication media are available to keep remote people in touch, and even achieve what's not possible in FtF context.

Numerous studies have explored the use of novel forms of remote communication beyond widely used phone and computer, creating various technological tools to reconnect distant people and maintain social ties. Common approaches for synchronous communication include shared media space [e.g.,171], awareness systems [e.g.,121;154], and remote tactile interactions [e.g.,119] to simulate touch sensations for remote people, while asynchronous communication mainly apply enhanced photo and calendar sharing [162], and manipulated video conversation [e.g.,84;150], etc. An overview of related works on technologically-mediated intimate relationships identified six broad strategies to create and mediate the feeling of relatedness: awareness, expressivity, physicality, gift giving, joint action, and memories [80], and each piece of work has focused on different aspects to achieve mediate intimacy. Lightweight, emotional, informal forms of communication

are being facilitated by systems that help people to effortlessly maintain awareness of each other's situations and activities [82].

Complementary to the developments of remote communication systems is a group of research that highlights the dimension of mediated co-experience. D. Fallman proposed the shift of interactive mediating technologies from task-orientation to user experience from the philosophical perspective [54]. Computer-mediated co-experience has mainly involved wider digital channels or modalities, such as shared multimedia files (e.g., photos, voice and videos) and daily activities, such as listening to music [102], joint exercise [120], collectively co-play [170], co-creation [138], and collaborative learning [8]. Specifically, K. Battarbee indicated the two forms of co-presence with multimedia messaging (MMS) are creation and interpretation. Co-experience is a process where participants together contribute to the shared experience in a reciprocal fashion, creating interpretations and meanings from their life context and allowing themes and social practices to evolve [13]. However, food has rarely been considered as a medium for mediated co-experience.

When co-located, people adeptly tradeoff between a wide range of cues, both verbal and nonverbal [134]. However, when examine the mediated communication tools we use when not co-located, we quickly see our

communicative channels restricted to primarily verbal channels such as text, images and speech. There is a need to explore nonverbal interfaces for non-co-located people with increased social cues. In remote communication, I hope food media could allow people to enrich their communication experience by multiplexing information and emotional communication channels.

On the other hand, with advanced technologies, use of food has gone beyond its traditional functions. Artists have adopted the rich properties of food for expressive performance [93]. Researchers have also used food as edible interface to display digital information [110]. In recent years, some HCI researchers focused on engineering developments in food activities like eating and cooking [122,167], or exploring the design implications and frameworks for interactive technologies to encourage sustainability, critically reflected from everyday food practices [22,32,64]. Differently, Edible User Interface (EUI) represents digital data using food, i.e., jellybeans counts to represent the allocation and release of system resources, and changed flavors of screen appropriate to user's task, trying to make information more memorable [115]. Three themes of recent food HCI works are: designing for engagement in more environmentally aware, socially inclusive, and healthier behavior [32,36]. Among them, the engaging social aspect of food is the focus of this research.

In the following sections, I will highlight three main areas of concern within this literature, including existing food-mediated communication that have been widely adopted, digital technologies with food, and technological attempts to mediate social food practices (e.g. shared dining). The review and analysis lead to the focus of this dissertation.

3.2 Food-mediated Communication

Food is a staple of our existence that also binds us together socially. To design new interactive systems around food, I need to understand how food mediates the current communication. First of all, I examined the current activities of food-mediated communication through the lens of Engeström's activity system [52]. I then reviewed the existing works that reveal different patterns of "non-mediated" eating under different contexts and food gifting.

3.2.1 Overview

Food itself is an instrument of social bonding, used for different members of a community (e.g., a family or group of friends or colleagues) to achieve a sense of togetherness when they eat together. The outcomes of such experiences can range from the development and renewal of social and family relationships to the closing of business deals. The shared dining experience can take place in a home or in a restaurant, but it is always mediated by a rich collection of rituals,

traditions, and etiquette. As a form involving nonverbal communication, the sharing of food also represents the most basic of all social codes [101].

The division of labor between food production, distribution, and consumption also has a special form when it comes to the social perspective, for example the giving of gifts. Food-related gifts are typically used to express social greetings or congratulations on special occasions (e.g., on a birthday or at Christmas, Thanksgiving, or New Year), where the technological mediation has been relatively less applied.

Food and eating are undoubtedly key aspects of societal practice. Meals are regarded as arenas for socialization of children into family and cultural practices [109], sharing food within a family or group setting is a way of expressing intimacy and friendship. In this way, the social aspects of food are oriented to and used as part of local mealtime activities.

3.2.2 "Non-mediated" Eating

Eating is arguably one of the most significant everyday occupations. Eating with others provides a valuable space for social contact. A number of studies investigated the behaviors and patterns of "non-mediated" eating for different people in different situations, refers to both quantitative and qualitative

features of people's selection and decision of foods, and the eating style resulting from psychological and social factors. They documented ways that social factors shape eating behaviors, such as quantity eaten, perceived peer preferences, interpersonal concern, etc.

One notion that has been widely explored is that eating behavior can serve a role in impression management. The experiment results from Pliner et al. indicated that behaving in a socially desirable manner could account for the eating behavior of males while for females both being socially desirable and appearing feminine could have affected amount eaten. Females ate less with male partners, especially if the male partner was portrayed as high in desirability. Males also ate less with a female partner, but the desirability did not have much affect [143]. Salvy et al. also conducted studies to examine how males and females adjust their level of eating as a function of their familiarity with and the gender of their eating companion. The results suggested that people strategically vary their level of eating with different audiences to fulfill a similar over-arching motive of a positive self-presentation. Although unfamiliarity suppressed both men's and women's food intakes, the matching effect operated only when a female co-eater was involved [155]. Furthermore, it was indicated that women showed higher

emotional eating and dietary restraint (both flexible and rigid control) than men, whereas men showed higher eating self-efficacy [144].

Different eating patterns between generations within a family have also been revealed. For grandparents' generation, mealtimes tended to be at the same time every day with the same meals served on the same days of the week, typified by a high degree of structure. Conversely, children appeared to be no universal structured eating pattern [91]. Dinnertime is a very meaningful ritual. As for dinner communication among parents and children, it was learned that girls spoke more did boys, and mothers were more active in conversation than fathers [51].

On the other hand, research exploring the effect of societal change on family structures and lifestyles indicates less time spent on food preparation, and greater consumption of convenience foods, often eaten outside of the home. Regular family meals are associated with increased family communication and cohesiveness. Longitudinal studies have provided a strong indication of the lasting benefits of family meals, including a positive influence on healthy eating patterns and disordered eating [1].

Sharing meals is a joint event. Engaging in activities together (such as eating) is one way in which the family can be constructed as a concrete and definable unit. The patterns of eating together vary for different ethnic groups. In most Asian countries, people sit around a table and share all the dozens of dishes together, while in Western dinners, each have their own plate of dish and enjoy it individually on the same table. Once food was on the table the parents would share the task of serving it to the children.

To sum up, people's eating patterns differ between genders, ethnic groups and social contexts, but the social communication is largely characterized by verbal conversation and the act of serving/sharing food.

3.2.3 Food Gifting

Food gifting is another widely adopted way of food-based communication. Food acts both literally and symbolically as a gift. People give or exchange particular food to others at various occasions like birthday, festivals, parties, and social visits. A typical example is chocolate. Boxes of chocolates are gifts with a romantic aura, since they are dark, wicked, delicious, and always with exciting filings. When visiting a home, it is considered good manners to bring a small gift (e.g. a dessert) for one's host. It is also considered thoughtful to bring back local food as gifts from a trip for friends and family.

In most contexts, food exchanges are the medium through which love, wish, and care are expressed. Symbolically, gifts are important in creating and reproducing social relationships among family members and friends. In the context of family, the things that people do for each other are considered acts of love and duty, such as the preparation and serving of food [109]. Food has been taken as an expression of love, most often prepared by a woman in the role of wife and mother: women viewed the preparation of a special dish or meal as way of treating their husband, while men are far less likely to use the preparation of food in a similar way [109]. In their study of British families, Charles and Kerr found that the mothers made special efforts to celebrate their children's birthdays with elaborate cakes and party food. This demonstration of their attention, love and affection was considered as gifts [29]. Gifting also takes the form of offering and sharing food, which shows hospitality.

A wide population, in spite of differences in gender, age, and ethnic groups, would welcome food as a gift. And food gifting can be performed within varied closeness of relationships. Although it often comes with a greeting card with sender's special expressions, or crafted with words on the food itself (i.e. cake, candy), I speculate the communication and expression through current

food gifting are mainly abstract - people select different foods in different contexts following routine etiquettes.

3.3 Digitalized Food-related Activities

Recent researches into food have not only suggested multiple points where technological interventions are possible, but also demonstrated a range of digital technologies with food and food activities, generating various types of "technologically-enhanced food".

3.3.1 Smart Cooking and Eating

One main group of technological intervention into food is the pool of research under "smart kitchen" theme. The "smart kitchen" typically presupposes a digital lifestyle, with the purpose of automating services and obtaining increased safety and security, comfort, communication and technical management [19]. Numerous works have developed robotic and assistive services to enhance food preparation. I discussed some of them in this section.

Cooking Navi [71] aims to help an inexperienced user to cook without failure, by providing users with appropriate instructions at the right timing. Similarly, the Intelligent Kitchen project uses a human activity recognition system to infer the next action based on previously observed human behaviors. This

system also includes a LCD touch panel to display a recipe with pictures and a mobile robot to suggest the next action using voice and gestures [125]. In the U-kitchen system, smart devices communicate with each other and share the context via a kitchen server, including RFID tags in appliances so the system can identify appliances being used, and ubiquitous services which help the user with the grocery management cooking and give healthy dining advice [3]. The Ambient Kitchen integrates data projectors, cameras, RFID tags and readers, object mounted accelerometers, and under-floor pressure sensing, to construct a supportive environment for food planning, preparation and cooking [130]. Also, researchers have developed a system that intelligently senses cooking activities and provides real-time nutritional information to help facilitate healthy cooking [30].

As for dining experience, Dining Presenter[2] detects the position of dishes and the amount of food to overlay a variety of information over a dining table using augmented reality, to enhance the visual appearance of food, dishes and a tabletop. "Future Dining Table" recommends dishes to the user visually during dining according to his/her context, by real-time recognition of the user's current activity, food remains, and the user's dining profile [85].

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[2] Dining Presenter. http://orange.siio.jp/ alumnae/mori/dining.html/.

All these works primarily focus on smart and assistive appliances; they mainly

provide contextually rich information while purchasing, preparing, cooking or

eating food to support those activities with more efficacy and smartness.

Although achieve a certain level of convenience for people, they don't address

the need for building social capital or facilitating remote social bonding. In

addition, they have the risk of overloading users with superfluous data. I feel

they ignore the social element of cooking and dining that could be supported

by digital technology.

3.3.2 Food Printing Technologies

Food printing is another potential technology that target at food. Machine-

controlled food crafting began in research and has resulted in commercially

available food printers.

Based on 3D printing principle, food printers enable highly automatic and

customized food production. They take in a digital design, and use liquidized

and viscous food (e.g., soft chocolate or melted cheese) as "ink" to create food

objects in an additive process. Designers who are not experts on food making

have applied this technology to create edible art, like Cookie Canvases[3], edible

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[3] http://www.npr.org/blogs/thesalt/2013/03/07/173720559/edible-bonsai-east-
meets-west-on-these-cookie-canvases

sugar sculptures[4]. Companies have impressed photos on chocolate or cake using food colors for business promotion.

In the research area, some pioneering works have explored the possibilities to transform the traditional food making using controlled printing. The CNC toaster uses a hot air gun mounted on a computer-controlled X-Y system to impress designs on a piece of toast, or a mounted cartridge can draw on liquids as well, like coffee surface [141]. CandyFab uses a bed of granulated sugar to build 3D prototypes using hot air sintering and melting [86]. The noodles printer from Fab@home [111] modifies a 3D printer that extrudes noodle materials into custom shapes. Solid Freeform Fabrication (SFF) of food from the Cornell Creative Machines Lab uses a personal fabrication system to produce multi-material, edible 3D objects from cake frosting, chocolate, processed cheese, and peanut butter [136]. Using modified ingredients and recipes, the creation of complex geometries and use of traditional techniques like baking and frying are also possible [106]. The MIT Cornucopia project proposed a number of designs and prototypes for digital gastronomy that address different fundamental processes of cooking [172] (Figure 3.1).

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[4] http://the-sugar-lab.com/
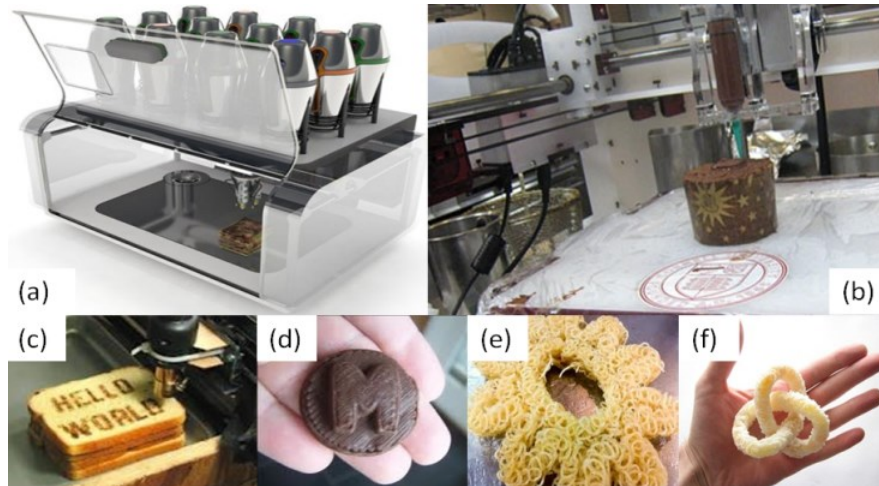
Figure 3.1: Gallery of food printing techniques: (a) Cornucopia from MIT (b, d) Cornell Creative Machines Lab's food printer and result (c) CNC Toaster (e) Fab@home's noodle machine (f) CandyFab's result

While the majority of food printing research targeted at improved quality and efficiency – e.g., resolution, shape varieties, complexity and delicacy of dishes, or speed of crafting – they are not motivated by an understanding of how this technology could impact people's social communication. Rather, I would like to extend food printing to communication as a technological celebration of food [67]. My goal is not to prepare exquisite dish automatically, but to enrich social communication through the use of food in ways that transcend culinary and productivity concerns.

3.4 Mediated Food Experience

Another group of works have moved from the "corrective technology" of "smart kitchen" to the "celebratory" design space of "Food HCI", which

suggested emphasis on the positive aspects of people's interactions with food including social connectedness, creativity and cultural engagement [67]. Following this, recent works have explored human-food interaction by embedding digital components into food and related practices, ranging from positive social concepts around human-food interaction and how technology can create new kinds of social engagements [19,81].

As for human-food interaction, "Mamagoto" [7] is an interactive and context-aware dining system that encourages children to "play" with food to expand their sensory experience while eating. DinnerWare [35] uses eating for aesthetic expression. It consists of a dining service electronically equipped to react to the food properties and respond to a user's gestures by displaying different patterns in the environment. Gamelunch [145] maps children's dining actions like cutting and slicing onto sound synthesis to increase the fun and encourage eating. Playful Tray [107] is an interactive game over a weight-sensitive tray surface, and uses children's eating actions as inputs for reducing their poor eating behaviors. These works used people's interaction with physical food to achieve individual entertainment while eating, not interpersonal communication.

A more closely related domain is the attempts to mediate the social experience involving food, such as cooking, eating, and tasting food. People always enjoy the communication while eating and drinking, and technological intervention could expand the breath of communication and interactivity via food, either through information broadcasting or the sensational feelings to supplement the current interaction format.

3.4.1 Shared Cooking and Tasting Food

Essentially, food involves many sensory, aesthetic and emotional aspects, and technology can potentially apply to all senses, smell, touch, and hearing as well [28]. Researchers have spent efforts on digitalization and transmission of these sensible feelings, and even sharing the experiences with others.

Flavor visualization [33] built connections between sensibility vocabularies of flavor and visualization expressions through literature and user study, and developed a prototype that could provide real-time visual expressions that guide taste varieties and intensities for individuals in remote co-cooking to achieve cooking dishes with similar taste.

To control and expand the taste sensation, researchers have produced two systems to change perceived taste of food and drink by electronically

stimulated the tongue with adjusted voltages via use of electrolyte of drinks and food [123]. In the case of two persons each having one straw in their mouths, this digital taste device could support the communication and enjoyment by changing the food flavor when they shake hands. Similarly, when one person helps the other to eat with the chopsticks/fork type of apparatus, the taste is also altered by the electric current that flows through the human body [124].

By transforming and digitalizing people's perceived sensations of food, these developments provided extra channels for mutual communication in the process of cooking and tasting food.

3.4.2 Social Eating Experience

Mealtimes are occasions used to forge and intensify social relationships. Media technology plays a big role in supporting people's social communication during eating and sharing of eating experience with others.

To encourage social conversation in the context of sharing a meal, a photo display system called 4 Photos was developed that collates photo mementos from meal attendees and displays them at the dining table to be interacted with by all. Through field study, it was revealed that interactions with this system

could contribute to the production of mealtime talk and mobilization of new and established social relations, in terms of getting to know others, shared reminiscing, display of affection and reinforcing family ties [132].

In parallel, with an increasing number of distributed families and friends, CMC technologies have been adopted to minimize the gap between people living apart and achieve shared eating experience in experiencing togetherness and playfulness. One main form is through sharing photos and videos online, where others could view, tag, and comment in an interactive way.

Teleconferencing lays the foundation for connecting remote people in real time. In regards to dining, the international consulting firm Accenture introduced a tele-dining prototype: Virtual Family Dinner to allow dines together in a virtual environment[5]. It is essentially a videoconferencing system with easy operation to be used by elderly. It automatically goes through a list of contacts when detects a meal dish on the table, trying to reach someone for a dinner chat. The website called Virtual Holiday Dinner[6] enables scattered friends and family to have dinner party of up to five people via Skype with humanoid robot dolls. At reserved time, guests call into the dinner, and their

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[5] http://gizmodo.com/tag/accenture-virtual-family-dinner
[6] http://www.virtualholidaydinner.com/

faces will display on flat screens that sit on top of the robot dolls physically around a dining table (Figure 3.2). The dolls are equipped with video cameras and facial tracking software, so each guest can look around the dining table by moving his/her head. Although it's reported to be totally awkward due to the robot doll, people enjoy the funny experience.

Figure 3.2: Concept and prototype of Virtual Holiday Dinner.

"NetPot" focuses on Chinese hotpot and identifies three key factors to maintain a group meal experience for remote friends: interacting as a group with food, a central shared hotpot, and a feeling that others are nearby [11]. The low-fidelity prototype creates avatars for each diner and projects the augmented food and chopsticks movement onto the other hotpot to maintain the interaction for online group meals. However, more realism is necessary to fully maintain these factors.

Figure 3.3: (L) NetPot system; (R) "Telematic Dinner": two groups in a shared toast and share a message on remote tables.

"Telematic Dining" attempts to reinterpret the traditional dinner party with CMC, highlighting the togetherness, performance and playfulness. It explores liveness of remote dinner by crafting a holistic dining experience among remote guests, which incorporated synchronous overlaid video recording and projection to enhance the realistic feeling [58]. Video is captured and projected from an overhead view. The respective remote guests' place setting, hands and arms were projected on to the tabletop. Based on investigation into users' behaviors and experience, they proposed the necessity to consider the social structure and cultural background of users to inform the design of a technological intervention.

In addition, researchers have also touched asynchronous communication considering time-zone differences between two locations, primarily by employing video recording and replaying. CU-Later (Figure 3.4) allows synchronizing dining activities across time zones by displaying a recorded

video of eating meals from a remote place after a time shift. As the video is played, the system records the local user's eating as well, so that the remote user the watch this later on. It connects two remote dining tables and lets users see and hear each other having dinner despite actually having done so at different times [165].
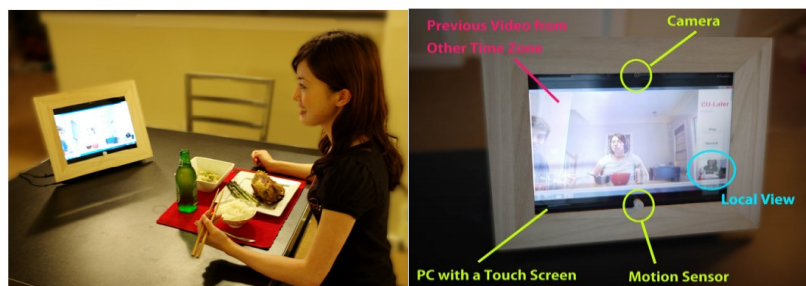
Figure 3.4: Concept and prototype of CU-Later system.

"KIZUNA" system furthers the potential of video exchange by highlighting the synchronization between two remote parties. It adapts the displayed video's playback speed to the difference in dining progress between the local and remote user, to enhance the communication experience and enjoyment [126]. Their followed study suggested that synchronizing the dining sessions between two remote parties would increase the realism of virtual social dining, sense of presence, and decrease the distracting of dinner talk.

These works identified the social values of shared dining, and have focused on recreating the mutual dining experience for remote people. They proposed various ways to rebuild connection and interaction with remote others during

dinner, mainly using digital projection, sounds and videos of the context. Although they successfully achieved enhanced communication and togetherness, they did not treat food as the center of communication. I consider media technology can be designed to better utilize physical interaction with food and accessories, to further enhance the communication realism, and also generate new interaction ways that do not exist in traditional co-located dining.

3.5 Discussion

Digital technologies have been applied to different dimensions of food and food practices. Not all technologically enhanced food was designed for mutual communication. The review demonstrated the significant research on enhanced food, but also pointed out the underexplored area of combining food and technology as a social medium. Previous works mainly targeted at intelligence and efficiency, or considered food as an output interface that may use changed flavors to represent digital information or to mechanically construct objects. As for the social experience involving food, most research focused on computer-supported telepresence, adopting projection, tracking and video technologies to simulate the chatting scenarios of co-located eating, without creating additional interaction channels. Furthermore, I am not aware

of studies that have looked closely at the manipulation and interaction process around food, and what aspects of this interactive process could yield insights into the design of technology and everyday rituals. In other words, they failed to put emphasis on the unique properties and affordances of food in the developed devices and interactive systems, and how technologies around food could enrich the existing communication. This research attempts to look into this aspect.

Indeed, modern food values focus on convenience and effortless, overshadowing other values such as communication and engagement. The rethinking of how we approach everyday food behaviors appears to be a particularly timely concern. In response, I aimed to explore the opportunities and challenges for the design of interactive systems for individuals' social connection on food practices.

3.6 Summery

Food is not simply a source of nutrition, but is also central to the production of community life, a site for personal and shared reflection and storytelling [20], a medium for social interaction and a symbol of personal identity. Food preparation and sharing in particular provide opportunities to support the creative, sensory, aesthetic and social nature of human-food-human interaction.

Furthermore, food related behaviors, such as shared meals, food creation, food preparation and so on, can all be considered to form an integral part of social and personal wellbeing.

I believe current literatures have overlooked two important points: the power of symbolic and interactive activities around food, and the multi-sensory quality of food as a social medium. I will explore how media technology can be incorporated to utilize these two properties, to enrich the way people interact through food and further enhance the mediated communication.

Chapter 4

Methodology and Roadmap

4.1 Methodology

This research attempts to enrich the current communication by constructing alternative communication ways using food and technology. Instead of focusing too acutely on ubiquitous sensory overload, I think it is also important to go beyond information to the level of enriched user experience with food, in other words, appropriating media technologies to achieve sustaining and pleasurable experience. *Food Media* aims to draw attention away from contemporary smart kitchen and dining media research, and make apparent the need for socially communicative, emotional assets investment regarding the space around food.

4.1.1 Design-oriented Research

With this goal in mind, I found it necessary to develop novel interactive scenarios that emphasize on interaction and engagement experience. My approach was "*Design-oriented Research*", where my efforts were primarily research focused and aimed to find an appropriate use of media to understand

and address a perceived human problem [53]. Fallman described this process

as which directed at large towards innovation design, and construction of new

kinds of information and interaction technology [53]. This research thus has

centered around the roles of food plays in specific social settings, to design

technologies in new ways as means of fostering meaningful personal

connection and communication.

4.1.2   Experience Prototyping

"Prototypes" are representations of a design made before final artifacts exist.

Prototyping is a key activity within the design of an interactive system, to

validate design ideas and encourage reflection. As Edwards et al. [50]

described, we should focus more on the "value for end users" than on the

"core technical workability". Since a design requires determining the technical

and users' motivated features to support the acceptable user experience, it is

necessary to construct the complete scenarios, in order to understand the

everyday practices of their users [160].

Experience is very dynamic, complex and subjective. M. Buchenau regards

experience prototyping as less a set of techniques, allowing researchers to

think of the problem in terms of designing an integrated experience, rather

than one or more specific artifacts [26]. Therefore, it is crucial to consider the

communication experience as a whole when designing and engineering the prototypes.

In design-oriented research, bringing forth the research prototype is also considered as a vital part of the research process. Daniel Fallman argued, "The knowledge that comes from studying the designed artifact in use or from the process of bringing the product into being is the contribution, while the resulting artifact is considered more a means than an end" [53]. In this research, the development of two prototypes was a means to explore the proposed approaches and uncover underlying insights for designing food-centered communication. Therefore, I also considered that my field of research was not focused on human or food machine alone, but the role of food and technologies in mediating communication and providing new contexts of communication. The main driving force was improving human communication in the world and understanding how technology can be crafted to be a tool and hidden into the everyday environment.

4.2 Research Roadmap

Following the above two approaches, the research steps I followed include: question exploration, setting the approaches, design idea generation, prototype

development, user studies and analysis. Figure 4.1 illustrates the overall

roadmap throughout this research.
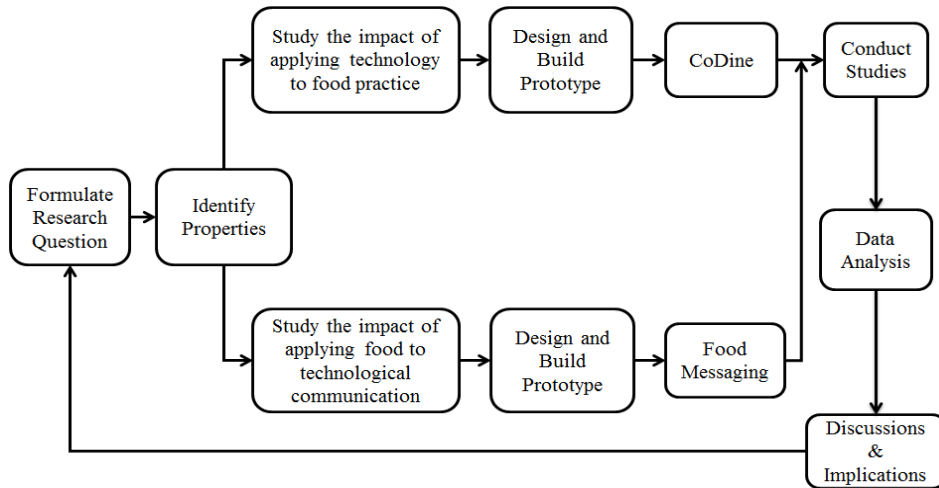
Figure 4.1: Overview of research framework.

To answer the research questions, I identified the exploration goal, which was

to utilize food's unique properties to enrich identified social communication,

and further investigate how food and technology could impact communication

experience in these specific scenarios. I then applied two approaches that

utilized such properties of food to mediate communication and social

interaction. I attempted to explore two aspects: how technology could

maintain and add new senses to food practices? And, how food could preserve

and add new senses into existing digital-dominated communication? I

developed prototypes to demonstrate two cases of alternative communication

methods between remote people.

Specifically, CoDine system utilizes interactive techniques to reconstruct the missing multi-sensory experience of food in remote dining. This case applied digital technology to enhance food-based social interactions. Food Messaging, on the other hand, uses food's sensory and emotional affordances to augment text messaging. This case utilizes food to enable an alternative messaging method, and transforms food into an affective medium of delivering and producing personalized food messages. The prototyping were driven by specific design goals (e.g., social presence, sensory and emotional impacts), while the common scope was to mediate communication by combining technologies and food.

In creating the prototypes, selection of technologies and implementation ways were examined carefully, according to their cost, availability, performance, and robustness. The objective is to create new communication experience with novel use of media technology. For example, controlled two-axis moving mechanism was applied in my CoDine system to move dishes on the dining table. Also by integrating hand tracking from the Kinect set, I designed a table surface to simulate the practice of sharing food and sense of hospitality.

After building the prototypes, I conducted multiple studies to uncover different dimensions of the two communication methods. I adopted several

methods, including laboratory evaluation, interviews, surveys and field study, not only to evaluate the systems' functionalities, more importantly, to construct the design space for the designed technologies, and further understand how they influence the communication experience, and why, i.e., what aspects of food lead to the influence. More specifically, I relied on the findings and analysis from these studies to 1) verify the design rationales; 2) discover usage pattern of food-enhanced communication; 3) identify the uniqueness of food as a social medium, in terms of people's motivations and perceptions regarding these new communication styles; 4) generate design implications for further research. In a word, based on the established quantitative and qualitative understanding of food-based communication, I analyzed the characteristics, unique values and roles of food combined with technology as a social medium and implications for future research.

Chapter 5

CoDine System

5.1 Overview

While people have a strong desire to connect with friends and loved ones over a distance, most communication technologies, like phone and email, fail to provide the same feeling of connectedness as one feels when are physically with them [88].

Eating is a social act, where people create, or recreate, a sense of warmth, belonging and togetherness with significant others. The act of eating together and sharing meals is known as commensality, an activity that not only preserves the physical body, but also creates and strengthens social bonds [113]. Noticing the growing lack of shared time between remote people, I designed and implemented the CoDine system to enrich the dining communication in a remote setting. As an exploration of new modalities to reconnect, the system is inspired by design research with people who are physically apart, but desired to maintain a close sense of emotional connection.

In this chapter, I begin with background evidences to highlight the social and cultural significance of dinner communication especially for distant families, which motivated my design. Next, I explain the design approach I applied towards experience-oriented communication. I then provide a comprehensive description of the system configuration, followed by detailed description of each module, and their integrated application into the whole system. After that, I report the evaluation and discuss how the designed interactions around food enhance the communication and interaction.

5.2 Background and Motivation

Our largely Asian culture sets in place the need to eat together so much that we value the concept of eating together at the table and take it as a primary way to keep connected with others. Mealtimes are not just an eating affair to nourish the bodies; but a sociable affair as well.

Food, cooking, and kitchens are often associated with an important set of experience in Western, as well as non-Western cultures [19]. Dinnertime is often a special moment in family life. For many, dinner around the table is a time to reaffirm cultural and familial identity, values, and ideals [158]. Through time spent together at meals, families establish roles and rules, share stories, build family traditions and rituals, and create a shared family identity.

Many of us have the memory of eating, talking and laughing when dining together with parents and grandparents. Food acts as a metaphor for family communication [112]. As Rae-Espinoza observed, "The family that eats together stays together" [149].

Traditionally in Asian households, the kitchen and dining room has been a place for families to connect and engage with one another, yet today's accelerated lifestyle endangers such nurturing activities. Eighty percent of parents in a recent survey viewed family dinners as very important, and 79% of teens considered eating family meals to be among their top-rated family activities; people want to eat dinner together, but lack the time or resources to achieve their desires [158]. Advances in technology are dragging people into the digital lifestyle, full of virtual communication, but lacking a sense of warmth and intimacy.

The social importance of dinnertime inspires my vision: reconnecting distant people through a computerized dining environment that enhances co-presence, which I call co-dining. Emphasis on the leisurely, communicative enjoyment of food expands the concept of communication beyond information sharing.

5.3 Experience-oriented Design

Technologies for connecting distant individuals have typically involved information exchange and purposeful messaging systems, rather than experience sharing. With the onset of affordable digital media and devices, communication takes many forms. In face-to-face situations, people use their full range of expression: language, facial expressions, gestures, and interaction with the artifacts and space. On the contrary, mediated communication has to rely on a more limited range: text, sound, image, and video alone or in any combination [13], when face-to-face is not available.

In the system, I concentrated on mediated co-dining, which means "social togetherness" for remote partners [65] during dining. To support co-dining, I was inspired by the concept of co-experience, which is driven by the social needs of communication and maintaining relationships. Experiences affect people's feelings through active involvement [131, p22]. Co-experience takes place as experiences are created together, or shared with others [59]. It is a process where participants together contribute to the shared experience in a reciprocal fashion, creating interpretations and meanings from their life context and allowing themes and social practice to evolve.

Interactive technology can play a large role in supporting co-experience, by providing mediated communication channels and the possibility of shared

physical activities. In the specific context of remote dining, my approach was to better understand what communication people usually adopt while dining together from my experience, and extend those activities into remote situations. Moreover, rather than depending heavily on the digital format like audio and video, I believe that interaction with the physical environment can be an important aspect for enriched and multi-sensory communication, which might contribute to the feeling of co-presence.

5.4 System Configuration

Transformed Social Interaction theory provided three dimensions for transformations during interaction involving novel techniques: 1) Situational context; 2) Self-representation; and 3) Sensory abilities [9]. Combining this framework with experience-oriented principle, I designed a dynamic and interactive prototype that draws on and learns from the rich cultural routines of dinner, and above all, focus on the human experience. I identified several social activities around the dining table to facilitate synchronous interactions, as shown in Figure 5.1, each mapped into the three dimensions.

Beyond video conferencing, I included activities like serving food (situational context dimension), expressing emotions (self-representation dimension), sending messages (sensory dimension), and integrated them into the CoDine

system in a tangible and shared manner. By augmenting the dining table, tablecloth and food with computerized devices, I modeled the multi-sensory dining experience with embodied extensions of communication, supporting the enhanced sense of engagement and co-existence. Figure 5.1 shows the actual set up of CoDine.
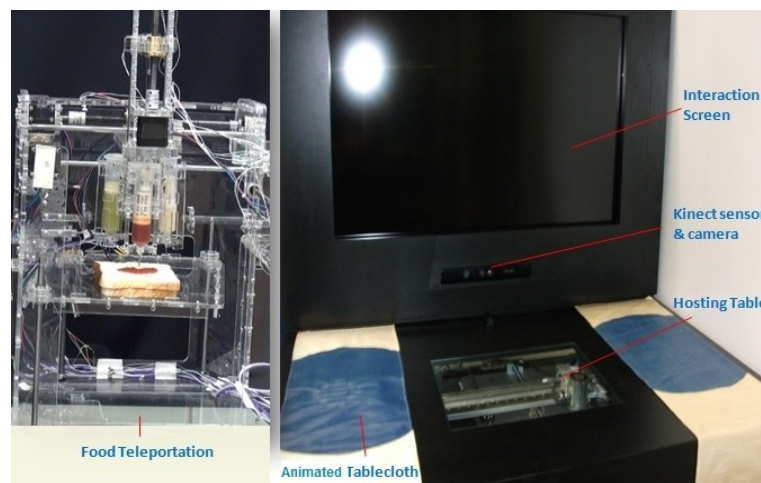
Figure 5.1: CoDine prototype overview.

5.5 System Description and Implementation

The CoDine system is supposed to be installed in a dining environment. As explained in Figure 5.2, the system consists of four modules, embedded into peripherals around food. The Interaction Screen, embedded with Microsoft Kinect sensor[7] and camera, works as the hub of the system, enabling the real-time interaction between the remote users. The three activity modules, Hosting

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[7] Microsoft Xbox Kinect. Http://www.xbox.com/kinect.

Table, Animated Tablecloth and Food Teleportation module, are connected

with and controlled by the Interaction Screen wirelessly through Bluetooth.
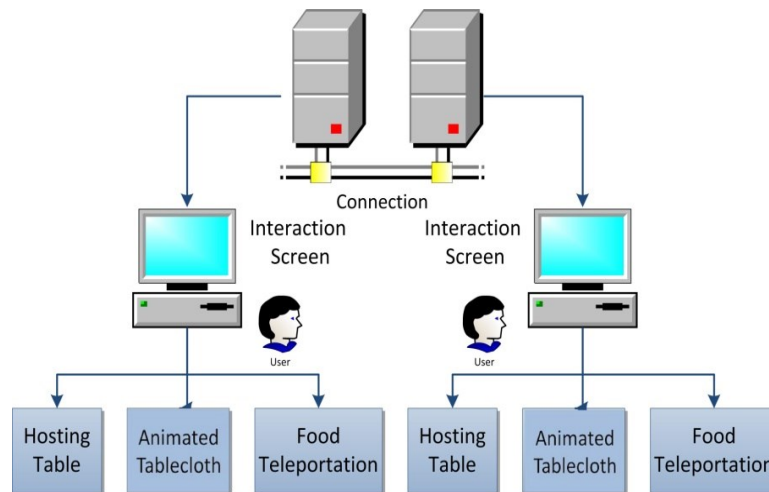
Figure 5.2: CoDine system configuration.

When people are dining at the table, their images, together with the dining

table surface, are displayed on the screen to achieve normal video

conferencing. To initiate any remote physical interaction, people move their

hands to choose icons on the screen. Figure 5.3 shows the gesture interaction

with the screen to choose different icons and Figure 5.4 shows the list of

possible dining activities and icons.

CoDine tracks the user's hand movement and transmits the icon chosen across

the Internet to the paired table at the remote location. This triggers the

corresponding module of the system on the other side to serve food, to display

pattern on the tablecloth, or create edible words. Compared with pure video

and audio communication, this system provides a wider range for effective

expression and interaction. It is through these shared physical messages and

activities that people engage themselves into the shared dining experience in a

reciprocal fashion.

Figure 5.3: Gesture interaction with screen to choose icons.

Subset module	Icon	Scenario Functionality	System Action in remote location
Hosting Table		Serving soup	Bowl with soup moves automatically to user
		Serving rice	Bowl with rice moves automatically to user
		Serving Pickles	Bowl with pickles moves automatically to user
Animated Tablecloth		Expressing Love	Animated heart shape appears on tablecloth
		Expressing Happiness	Animated smiling face appears on tablecloth
		Expressing excitement	Animated exclamation mark appears on tablecloth
Food Teleportation		Sending food message	Food-made message "LOVE" printed on toast

Figure 5.4: Dining activities the user can select.

5.5.1 Hosting Table

One of the shared dining activities I designed is serving dishes using the

Hosting Table module. Eating food together always creates a warm

atmosphere that keeps people happy, occupied and entertained. Considering one of the positive aspects about communication while eating together, I developed this module to mimic the mutual food serving in dining situation to provide the warm feelings of pleasure and intimacy. In many Asian cultures, serving food is a conventional dining etiquette to show respect, love and care to family members and guests as well[8]. This tradition has been deemed as a kind of spontaneous activity in our culture, something that we regularly and unconsciously engage in. Using this module, I attempt to bring back this ritual dinner etiquette and derive emotional pleasure from this physical interaction via food and tableware, even when people fail to share the same dining table.

To support remote food serving, I designed a controlled moving mechanism and embedded it into the normal dining table. The mechanism applies the basic principle of magnetic attraction, combined with two-axis linear movement. Permanent magnets are attached on the bottom of the dishes, including bowls and plates. The whole set of structure is put underneath the table and then covered by a piece of glass. By controlling the movement of electro-magnet component underneath, I can control the movement of dinnerware on the table. I chose to use magnets because they are simple to

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[8] http://www.advancedetiquette.com/newsletter/feb05_issue.htm

implement, easy to control, and require no wires. When the master controller receives the activation signal, the motors and magnets are activated accordingly to execute the remote moving of dishes, which give a visual illusion of "magic moves" on the table surface.
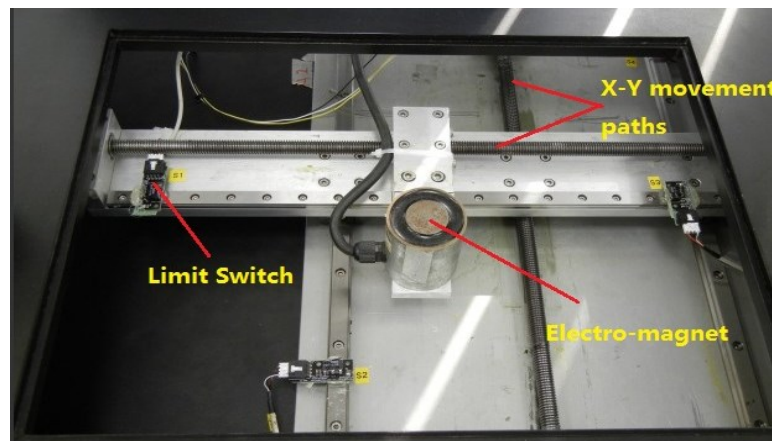
Figure 5.5: Implementation of Hosting Table mechanism under dining table.

The structure under the table is an electromagnet component installed on an x-y plotter structure (Figure 5.5). Both axes have two limit switches for safety reasons, also for initial position recognition. The movements of motors, activation of electromagnets and wireless communication with the screen are controlled by an 8-bit microcontroller from the master board, embedded with a Bluetooth module.

The Hosting Table, installed as part of the dining table, is integrated with visual interface through Bluetooth protocol, achieving a user-friendly interactive experience based on gesture. For the prototype, it is designed to

serve three different dishes. At the beginning, three bowls with different food are put along the farther side of the table, and the electro-magnet in its initial position. When user on the other side selects one of the dish icons from the screen, let's say, serving the rice dish on their partner's table, the electro-magnet will move directly to the position of that dish, activate the magnet, and drag the rice smoothly towards the user on the table surface. Figure 5.6 shows the actual dish serving after the user selected the serving rice icon.
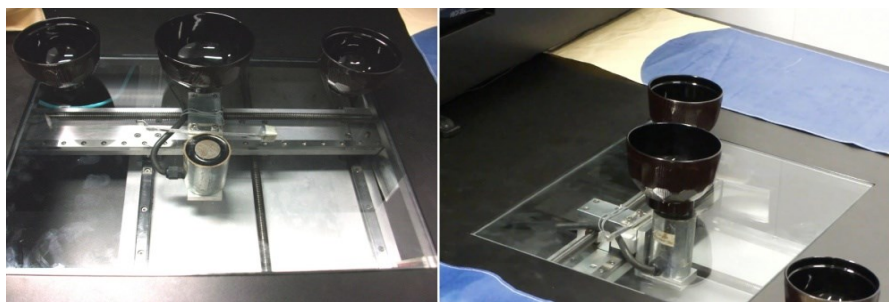
Figure 5.6: Results of Hosting Table when serving dish remotely (L) Original; (R) Second dish selected.

In the current implementation, the electromagnet component attached to the Hosting Table is designed to move smoothly in x-y dimensions, with a range of 300mm and 400mm respectively. For initial position recognition and avoiding accidental oversteps, limit switches were mounted on both axes to interrupt the movement when necessary. For the purpose of dishes serving, the speed and smoothness of movement are key factors to simulate the natural feeling. Many experiments were conducted on different surfaces, matched

with suitable magnet force and moving speed. A glass surface was finally used to reduce friction and avoid wiggling effect. To keep the balance between the speed and the natural sense, I set the speed to 16mm/sec in both x and y dimensions, meaning that a dish can be served to the user in about 15 seconds.

Compared to interacting in a virtual environment, I believe these physical movements of plates or cups physically on dining table convey more delicate human emotions and stronger feeling of warmth in non-verbal ways, which contributes to the enhanced sense of co-presence when user take the served dish from their remote dining partner. The synchronous communication is established and even though they do not share the same physical dining table, which transformed the specific interaction under the dining context.

5.5.2 *Animated Tablecloth*

Communicating the subjective emotions is not restricted to the use of emotion words. The Animated Tablecloth extends the co-dining experience to another component of the dining table, the tablecloth. By introducing the dynamically color-changing and interactive tablecloth, CoDine enables the delivery of emotions, which transforms the self-representation dimension of mediated communication to further enhance the communication experience.

The tablecloth is implemented to display several slow-rate animations through controlled color changing on fabric. The special-designed tablecloth is placed on top of the dining table, which applied a non-emissive display technology to display the patterns triggered by the icon selection from the interaction process.
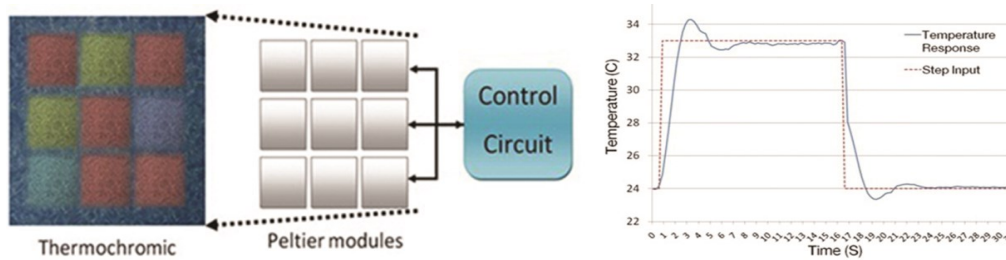
Figure 5.7: Implementation for the Animated Tablecloth: (L) Basic mechanism; (R) Transient response of one Peltier element.

To achieve this functionality, I am currently using thermochromic inks combined with Peltier semiconductor elements [135]. The basic structure is depicted in Figure 5.7 (L). The tablecloth combines Peltier semiconductor modules and thermo chromic leuco dye ink technologies using a closed loop control system, employing a PI (proportional, integral) controller in order to accurately control the color. As thermochromic inks are thermally actuated to change color, I chose the Peltier semiconductor modules due to its rapid thermal actuation capabilities within a wide range of temperatures. Current inks actuate at 32 degrees (colorless) and regain the original color of brown at 24 degrees. In addition, Peltier elements can reverse their function from

heating to cooling or vice versa by reversing the polarity of the supply voltage.

This allows both heating and cooling of the fabric (a screen printed with

thermo chromic ink) dynamically, to achieve a subtle and fast animation effect.

This is an advantage compared to most current technologies using thermo

chromic inks that only include a heating function. Without a cooling function,

cooling must be done naturally, slowing down the bi-directional color change

process and preventing the bi-directional animations of the fabric possible

with this approach.
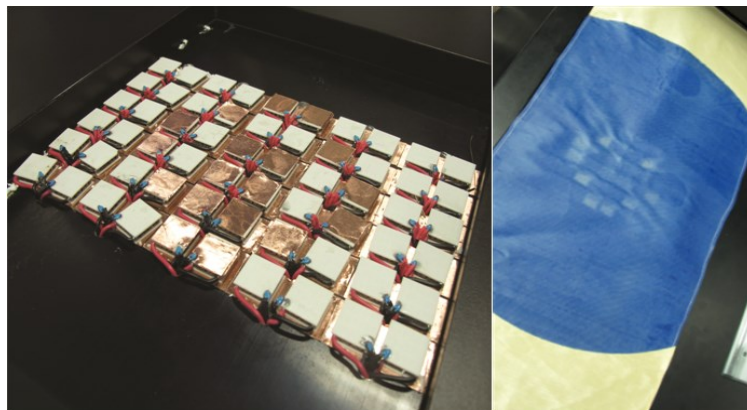
Figure 5.8: Matrix arrangement of Peltiers for the tablecloth display.

In the current implementation, a pixel display mechanism is applied to achieve

the accurate display of various patterns. As shown in Figure 5.8, 60 Peltier

modules (1.5cm*1.5cm each) are arranged in a 6*10 pixel display pattern, and

the whole display is 20cm*12cm, which is covered by the specially made

cloth. Fifteen control circuits with each circuit individually controlling four

Peltiers are connected to a master controller using I2C protocol. Each controller uses a single microcontroller with internal oscillator running at 8MHz. Four PWM (Pulse-width modulation) signals are generated using internal timer interrupts at 100Hz. The duty cycle of each PWM signal is controlled by the PID control module (proportional, integral, derivative), which implemented in the microcontroller with the four temperature feedbacks. In this way, each of the four Peltiers is accurately controlled for temperature using a single controller circuit. The master controller connects to the screen interface wirelessly using the Bluetooth. Once the display patterns are received, the master controller issues commands to each of the control circuits to turn on or off one or one set of Peltiers according to the specific pattern.
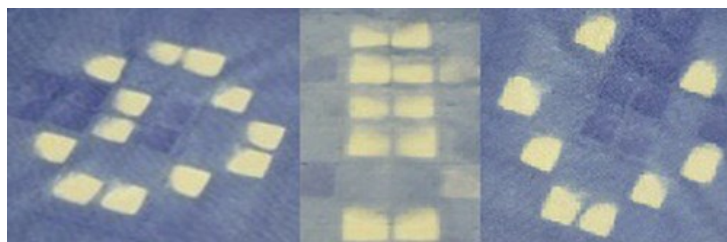
Figure 5.9: Different pattern display on Animated Tablecloth: (L) Heart pattern (M) Exclamation mark (R) Smiley.

The quality of response for Peltier element is quite essential to achieve an animated display and pattern changing accurately. Figure 5.7 (R) depicts the transient response of a single Peltier element. The rest of the Peltiers in the arrangement behave similarly. As observed, the rise time of the system is

approximately 1.5s (to go from an ambient temperature of 25 to 32 degrees).

In addition, the cooling time also takes approximately 1.5s, which is an important characteristic for allowing subtle bidirectional animations on fabric. Some of the resulting patterns are as shown in the Figure 5.9.

The animated tablecloth provides an added channel for emotion expression between remote diners. It allows users to convey their particular messages in an animated, but tangible way. Furthermore, the shared social space extended to tablecloth not only makes the communicated expressions easier to recognize, it also makes people feel more involved. I feel receiving an animated display on the tablecloth would be surprising and pleasant, and stimulate an enhanced feeling of co-presence beyond receiving a plain text.

5.5.3 Food Teleportation

Dinner cannot exist without food, of course. Besides table wares and tablecloth, I believe edible food can also be an expressional channel to enhance the emotional connectedness for remote families. Although it is almost effortless to send Short Message Service (SMS), photos or digital gift, these intangible messages miss out the physical and emotional sense of care. Instead, imagine receiving an edible "Hello" from your remote family members during dinner. Food Teleportation achieves this by reproducing the

digital greetings (i.e. messages and gift) using edible food materials, creating personalized greetings in edible format.

To teleport food, people select the Food Teleportation icon on the Interaction Screen, which triggers the remote food teleportation module, and prints out a digital message in edible food. Loved ones would receive this message-embedded food as a unique gift, which shows greetings and care physically. Compared with digital message, I suppose expression through food can convey a stronger sense of presence with enhanced sensory experience. It is more than simply saying "I love you" or "I miss you", it is a physical embodiment of care and affection of one person to others [137], not only visually, but also with smell and taste.

Structure Description

The food printer deposits ingredients in an additive, layer-by-layer process using a 3-axis robotic carriage. This process builds up into three dimensions with multiple ingredients using accurate step-motor control and triple-syringed food-material injection. The mechanical structure of the subsystem contains two main parts: (Figure 5.10)

1. 3-axis mechanical structure with robotic carriage.

2. Food depositing component with 3 syringes.
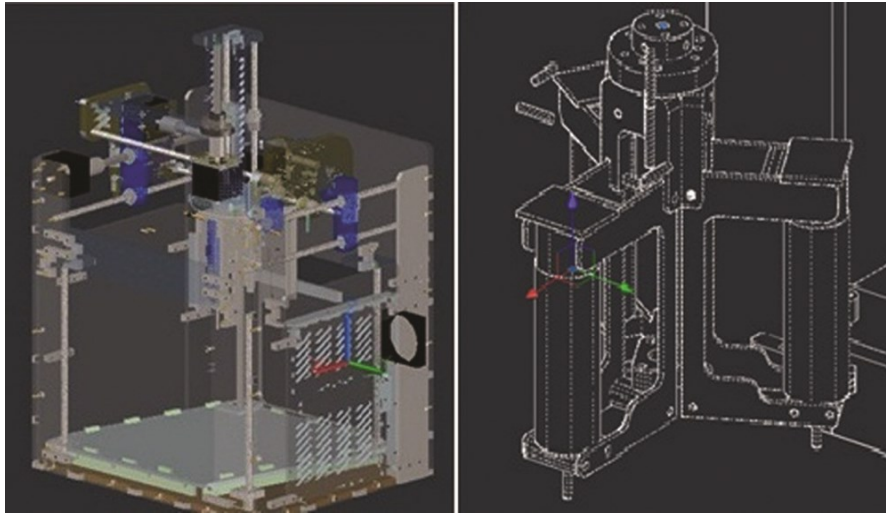
Figure 5.10: Structure assembly: (L) The whole mechanism; (R) Food deposition component.

The mechanical structure is a custom-built 3-axis model of Cartesian X, Y, and Z type. Essentially, the model is designed to use 3-degree freedom robotic carriage to move the food-depositing component along the x and y axis and the platform up and down to form z coordinate of the system. The accurate and smooth movement of each axis is achieved through lead-screw coupling powered by step motor, controlled by microchip PIC32MX340F256H from the master board. One step motor pushes a piston that injects the food, while another motor rotates the whole food-depositing component to change the ingredient when necessary. Through balancing the coordinate movements of syringe position and food extrusion, this mechanism is able to form the designed shape. Figure 5.11 shows the actual appearance of Food Teleportation mechanism and the fabricated master board.
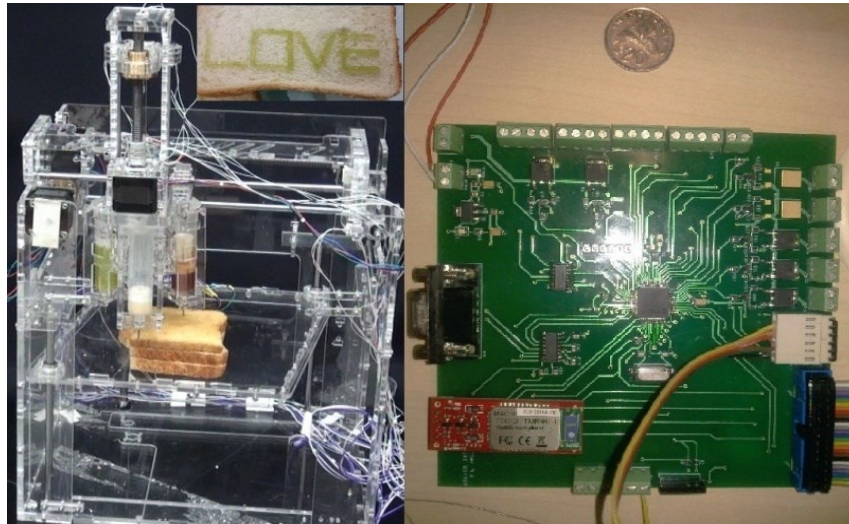
Figure 5.11: (L) Food Teleportation mechanism with its initial outcome; (R) Design of Master Board.

The food-depositing component was designed exclusively to enable food heating, extrusion and materials change while moved by the robotic carriage. A flexible heater can be attached around the syringe and connected with the master board, to heat up the food material that needs to be liquefied before been dispensed. Also, in order to know the exact volume of food material at each beginning of a new material, tiny limit switches are installed under the pushing pad and connected to the mater board for position sensing.

This mechanism, connected with the CoDine system, allows users to reproduce interpersonal digital messages in a remote location using normal food and present to their preferred recipients physically. After receiving the user's chosen message from the interaction, the coordination of the starting point and the motion path for the pattern are interpreted and sent to the module

on the other side, to be re-produced layer by layer. When finishing crafting the top layer, the platform will move down a certain distance to continue with the next layer. Through this layer-by-layer printing, a 3-dimensional food message or tiny gift could be constructed. Figure 5.12 illustrates the working flow of the Food Teleportation mechanism.
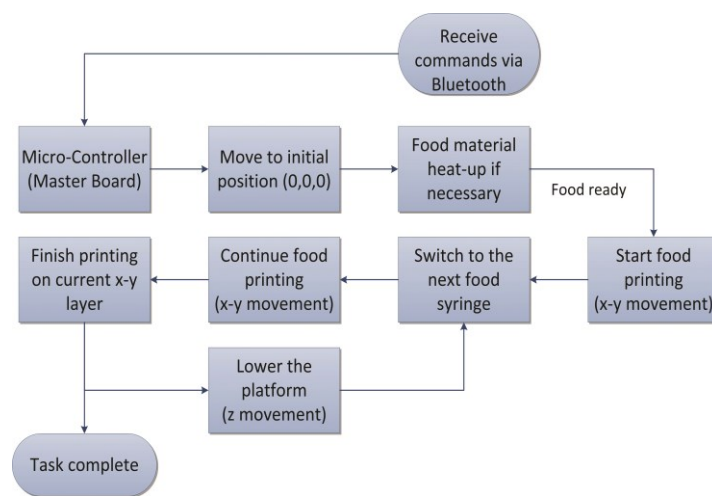
Figure 5.12: Flowchart of the Food Teleportation module.

Although currently selecting the Food Transportation icon sends a single message, "LOVE", the Food Teleportation subsystem is designed to craft with multiple food materials, not only to make the food message colorful visually and more tasty, but also enable the creation of contextual messages with changed color, smell and flavor, to represent different emotions or feelings. I have experimented with different kinds of food such as chocolate cream (pure black chocolate, white chocolate and milk chocolate), sugar-water mixture,

Kaya jam, peanut cream, etc. I also included the most important staple food for Asian households, rice. Food here is the multisensory medium for family communication, and each flavor can be translated into a corresponding emotional state or special experience from one's memory. This flavor-changed eating experience of food gift acts as an intuitive and meaningful way for emotional expression.

Integrated into the CoDine system, people can achieve transmission of affective message during dinner, either by printing the chocolate-made message on a piece of toast located in their grandparents' kitchen, or teleporting a muffin with different food materials in each layer to express their complicate and indescribable feeling, or sending a message using different natural rice. The richness of the message content is much increased with the inclusion of other senses, like color, image, even smell and taste, not only because they provide a richer, multisensory description of reality, but because the elements together provided more possibilities for interpretation: emotion, mood and humor [13]. When messages are sensed, they become the object of social interaction [131, p149]. I believe the transmission of physical and multi-sensory message is quite promising to contribute to the feeling of co-presence for remote family members.

5.5.4   Interaction Screen

The Interactive Screen integrates these three activities seamlessly to achieve intuitive interaction experience. It is designed to allow users to easily select the activities he/she wanted to perform while dining. Figure 5.4 showed the dining activities implemented in the CoDine prototype. Using hand gestures towards the Interaction Screen, people can choose to serve dish, display an expressional pattern on tablecloth, or send edible greetings.

Several interaction methods were considered, including a touch screen and buttons. As the screen is about one meter away from the user, the distance makes the use of a touch screen inappropriate. In addition, the table is to be used for dining purpose, so placing buttons on the table is not user-friendly either, since the user may press the buttons accidentally. Hiding the buttons at the bottom or on the side of the table would make it difficult for the user to see and select the buttons. After comparison, I decided that the most natural interaction in this scenario was to use gesture recognition with on-screen display, so that the user can select an activity using simple and natural gestures.

The Interactive Screen module includes a Kinect sensor bar and gesture-based on-screen menu selection. One RGB camera inside the Kinect sensor supports traditional video conferencing, allowing the user to see his/her remote dining

partner and the partner's dining table. It captures image at 8-bit VGA resolution (640*480) at 30Hz. The stereoscopic 3D camera embedded into Kinect is used to capture and compute the depth of the current frame image. A gesture-based menu selection allows the user to easily select the actions that would be performed on the remote side. Figure 5.13 illustrates the technical workflow of the Interaction Screen. The signals received from tracking the user are transmitted to the remote location, triggering the corresponding subsystem through Bluetooth, which supports food serving, tablecloth display and food teleportation.
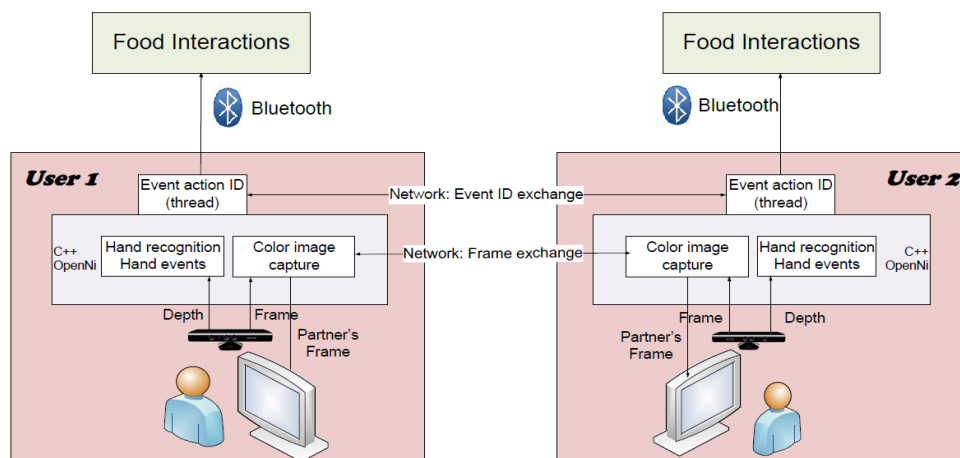
Figure 5.13: Workflow illustration of Interaction Screen.

The gesture detection is achieved by using a Kinect sensor bar, the OpenNI[9] 1.0.0 API and PrimeSense[10] NITE 1.3.0 Middleware. The API provides some methods to easily detect and track the user's hand. Various gestures can be

[9] OpenNI: http://www.openni.org/.

[10] PrimeSense: http://www.primesense.com/.

detected. In this module, I chose to use the following three gestures based on their naturalness and recognition accuracy.

1. Raise-hand gesture: User raises his/her hand.

2. Hold gesture: User holds his/her hand at a certain position for 2 seconds.

3. Push gesture: User pushes his/her hand towards the camera.

Besides the hand tracking and gesture recognition, different colors are mapped to different cursor states to improve user's understanding of what is currently happening. Colors make the visual system much friendlier.

The screen interaction is designed as follows:

1. To select an action, a user performs the Raise-hand gesture. When his/her hand is detected and tracked, a blue point shows up on the screen, indicating the control pointer. The screen implements an offset shifting mechanism to make sure the user can reach the whole screen without too much movement.

2. By default the menu icons are translucent to avoid distracting the user from the video conferencing. When a user moves his or hand over an icon, the icon lights up to give user the feedback of interaction.

3. If the user wants to select an icon, he/she can perform a Hold gesture by focusing the blue pointer on the icon for 2 seconds. The pointer will turn green, indicating it is now waiting for the confirmation gesture.

4. To confirm the selection, user performs a Push gesture towards the camera. After a successful push, the control pointer changes to red and a message is displayed on the screen's top left corner to verify the chosen action. This signal will be transmitted through the network to the remote location, and trigger the corresponding subsystem via Bluetooth. Alternatively, the user can cancel the choice by moving away from the button area.

5. After the desired icon has been selected, other interactions are possible while the previous selected action happens remotely (e.g. serving food, transporting food, displaying picture on tablecloth) is still continuing. The interactive session ends when the user rests his/her hand on the table, ending hand tracking. Then, the menu automatically disappears, returning the Interaction Screen to the normal video conferencing mode.

Overall, the integrated CoDine system provides a mediated platform to enrich the mealtime interactions for remote families, with the purpose of enhancing the feeling of co-presence while dining in different locations. Through embedding computerized devices into normal dining table, a series of intuitive

and interactive activities during shared eating are accomplished to support the feeling of social connectedness. Figure 5.14 is a photo taken during the prototype testing which demonstrates how the system works. The testing was to verify the functionalities and robustness of the CoDine system.

Figure 5.14: Demonstration of how user communicates during remote dining.

5.5.5 *Summary*

CoDine was designed and implemented as an exploration of using interactive media in eating scenario to reconnect people, generating cohesive eating experience. To facilitate and enrich co-dining, the system augments and transports the experience of communal family dining. Through shared dining activities, including serving dishes remotely, transmitting animated textile display and physical edible message, CoDine aims to provide a new solution for remote communication, by connecting the dining experience and creating a sense of co-existence among close people who may be physically apart.

5.6 Evaluation

To obtain real feedback, it is important to evaluate the pervasive applications in a realistic environment. However, testing a design *in situ* is time-consuming and prohibitively expensive [104]. This section describes the preliminary evaluation with this interactive multi-sensory system. It aimed to investigate the effectiveness of the working prototype on enhancing social presence and communication during remote dining. Since the system design mainly focused on the enhanced communication experience triggered by cultural recall, physical interaction and engagement during dinner, I leveraged on these three main aspects. The study results revealed that this system could potentially achieve the sense of "being together" and enhanced engagement between remote co-diners, through the interactive activities touching upon tableware, tablecloth and edible food, and each interaction module contributed differently to the overall experience.

5.6.1 Study Overview

I recruited 29 volunteers (17 male and 12 female) using convenience sampling. They are aged from 20 to 40 years old and have different social backgrounds, such as students, designers, admin staff, researchers, and engineers, coming from different countries, like China, India, Japan, Sri Lanka, Korea, and Spain.

Figure 5.15: System set up in the evaluation.

After explaining the general concept and how to use the system, I asked each participant to try the prototype for about 15 minutes freely, 5 minutes for each module on average. Figure 5.15 shows the system set up in the evaluation session. In this study, I did not apply the remote paired setting; users can activate all the modules and experience the corresponding output directly at the same location. It was easier for them to understand how the system works and obtain clearer impression to tell their perceptual feelings, helping us to access the system's potential effectiveness in paired setting. Then I used the post-study questionnaire to elicit their responses about what have been designed, in terms of usability, engagement, and the emotional experience it evoked. The participants were given the questionnaire right after their usages.

Besides demographic data, the questionnaire includes two parts. The first is about their life experience of family dinner, like how frequently they have dinner with families previously and currently, what tools they use, and the importance of family dinner to them, etc. The second part is for their feedback on the prototype, both the integral system as a whole and each individual module. I used the Likert Scales [166], a series of statements to which the respondents rated their level of agreement on a 5-piont scale. The rankings from 1 to 5 indicate from "Strongly Disagree" to "Strongly Agree". What's more, in order to avoid the "social desirability bias" [166], I collected the post-test data in a way that the evaluator did not see the responses until the participant has left.

5.6.2 Evaluation Results

From the demographic data, I noticed most participants are foreigners, either study or work here, thus live away from their families. The unavailability to have dinner with their families regularly and their strong desire for this make them suitable as the potential users of this system. I reported the collected questionnaire data below, expressed by histogram in percentage.

5.6.2.1 User Responses Overview

This study tries to evaluate how the system can support communication during remote dinner through multiple interactive dining activities, especially people's emotional feelings. In the questionnaire, I focused on five main items:

- It could provide the feeling of co-dining (dining together physically);

- It could enhance the engagement between co-diners ("I feel involved into the shared eating, and focus on the communication"), compared with pure digital connection such as video chatting;

- Interactions through physical objects could enhance the feeling that "we are eating together physically";

- It supports cultural awareness (recall some cultural elements, e.g. social norms, traditions, etiquette) of family dinner;

- The interactions over dinner are natural (not awkward).

Each user should rate their agreements on these five items towards the integral system, and also for each subsystem individually.
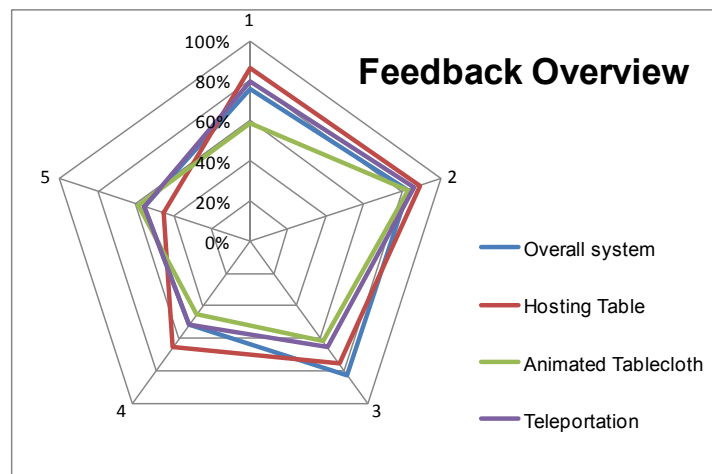
Figure 5.16: Radar chart of the overall feedback (percentage shown is the sum of rate "4" (Agree) and "5" (Strongly Agree) in the questionnaire.

Generally, users rated higher for the first three statements than the last two (Figure 5.16), indicating that both the integrated system and the three modules individually could provide co-dining feeling, increased engagement and sense of "being together" (around 80%), but did not achieve the expected cultural awareness and naturalness so well (50%-60%). Respectively, 76% of the users rated positively (Strongly Agree & Agree) for the co-dining feeling, increased engagement and enhanced sense of "being together" through tangible interactions, while only 52% confirmed the cultural awareness. Among the three activity modules, Hosting Table got the most confirmation regarding the co-dining feeling, the engagement, the sense of "being together" and the cultural awareness, except the natural interaction aspect. Compared with Hosting Table and Food Teleportation, Animated Tablecloth generally did not obtain as high ratings, but appeared to be a natural interaction for the users.

5.6.2.2 Effectiveness of the Integrated System

The purpose of first two statements was to evaluate the triggering of co-dining feeling, and the contribution of tangible interactions to the feeling. Reviewing the data in Figure 5.17, I got very positive ratings on both aspects. A majority of users (76% and 83%) agreed on the fostered co-dining feeling and the sense of "being together physically" provided by the multifaceted interactions.
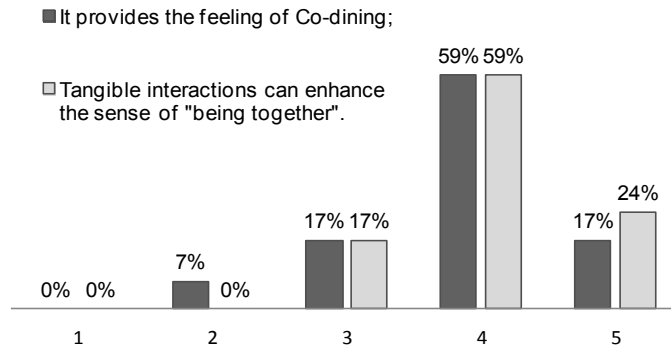
Figure 5.17: Effectiveness of the integrated system.
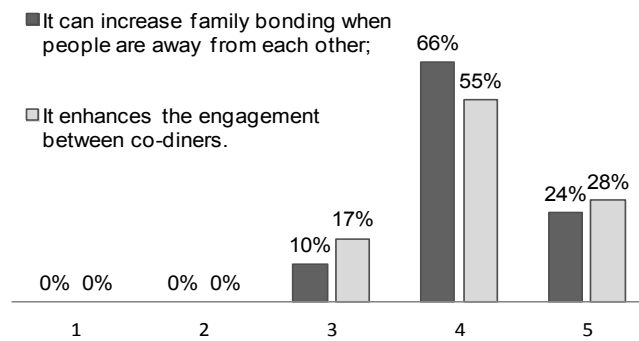
Figure 5.18: Users' emotional perception.

Post-study questionnaire is an important method to collect self-reported data.

At the emotional level, self-reported data can also tell how the users feel about

the system [166]. Therefore, I included statements to obtain users' emotional

perception while using the system. Shown in Figure 5.18, none of the users

disagreed with the statements about increased family bonding and engagement

experience from the system, 66% agree and 24% strongly agreed that the

system would help to reconnect the remote family members, 55% agreed and

28% strongly agreed on the enhanced engagement while dining.

5.6.2.3 Cultural Awareness

As acknowledged, family dinner is a social event correlated closely with culture, interwoven with and represented by the ritual and habitual manners people conduct during a family dinner. One intention here is to interweave the cultural association of food and eating into mediated communication.
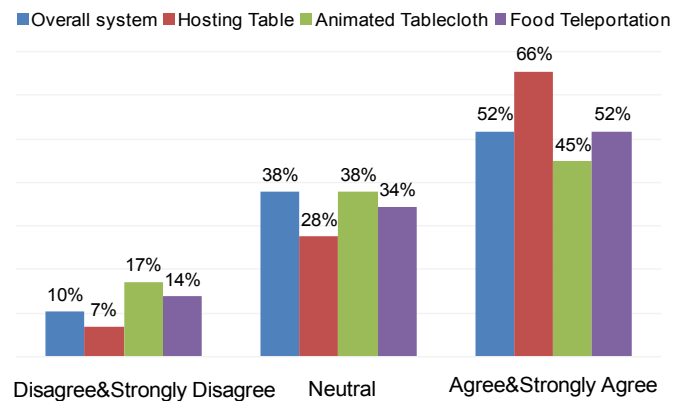
Figure 5.19: Cultural awareness of family dinner.

Cultures of family dinner vary according to the regional, religious, historical and ritual traditions, including the dinner manners and the varieties of food ingredients. This system provides a snapshot into one aspect of family dinner culture. From Figure 5.19, 52% users rated positively for the integrated system on raising cultural awareness, indicating the experience was not as strong as expected. This was reasonable, because cultural awareness is relatively subjective; participants may have different knowledge about dining culture, especially between people from eastern and western countries. In this study, I had a multi-cultural group of participants; it was found that participants from

western countries did not feel obviously the system could raise cultural awareness. Among the three modules, 66% participants agreed that Hosting Table could raise cultural awareness, indicating that remote tangible interaction achieved by the Hosting Table could potentially recall the traditional dining etiquette of serving food even if people fail to share the same dining table, which is considered as an important social activity with symbolic cultural meanings especially in Asia. Specifically, participants reported a mean value of 3.76 (SD=0.951) for Hosting Table, 3.31 (SD=1.04) for Animated Tablecloth and 3.45 (SD=0.948) for Food Teleportation.

5.6.2.4 Effectiveness of Each Interaction Module

I assumed that each interaction module designed in the system contributed differently to the overall experience; therefore, analyzing users' assessment on each individual interaction module would be more targeted for me to improve the design; probably different combinations of these interaction modules can achieve a higher level of co-dining experience for the users.

- *Statement 1: It provides the feeling of co-dining.*

As mentioned, the main purpose of this system is to provide the "co-dining" feeling, defined as the sense of "being together" physically. Repeated-measure ANOVA showed a significant difference among the three modules, $F_{(2,56)} =$

9.150, $p < 0.001$, indicating that each activity module contributed differently to the overall co-dining experience. In comparison (Figure 5.20), I would infer that Animated Tablecloth had less effect on people's co-dining experience than the other two, since quite a lot rated "Neutral" and only a small amount rated "Strongly Agree".
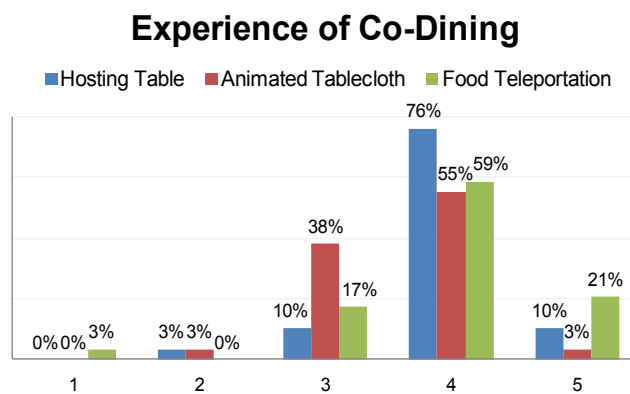
Figure 5.20: Feedback of each interaction module towards Co-dining feeling.

The possible reason for this phenomenon could be: from users' perspective, instant responses from the remote side were more effective to trigger the sense of "being together", and the slow-rate animation on tablecloth did not achieve that so successfully. Interestingly, although a very large portion (86%) agreed on the contribution of Hosting Table to the co-dining feeling, most rated "Agree" rather than "Strongly Agree", while more users rated "Strongly Agree" on Food Teleportation. What I infer was: Food Teleportation could trigger more intensive emotional impact than Hosting Table. All the three

interaction modules are significantly associated with the overall experience (Pearson's r > 0.7, p < 0.01), and Food Teleportation has the highest coefficient (Pearson's r = 0.898, p < 0.01), suggesting that it may play a more important role in determining the overall co-dining feeling of CoDine.

- *Statement 2: It enhances the engagement.*

Regarding engagement experience, repeated-measure ANOVA showed no significant difference among the three modules, $F(1.641, 45.948) = 1.829$, p = 0.178, suggesting that there were no significant differences among them in terms of their contribution to the overall engagement experience. All the three interaction modules are significantly associated with the overall experience (Pearson's r > 0.8, p < 0.01), and Animated Tablecloth has the highest coefficient (Pearson's r = 0.866, p < 0.01), suggesting that it may play a more important role in determining the overall engagement experience of CoDine.

Participants reported a mean value of 4.11 (SD=0.557) for engagement from Hosting Table, 4.00 (SD=0.643) from Animated Tablecloth, and 4.11 (SD=0.860) from Food Teleportation (Figure 5.21). Participants admitted that compared with pure video or audio communications, these shared interactive activities would enhance the engagement during remote dinners, making people involved and focused on the communication.

Engagement Experience
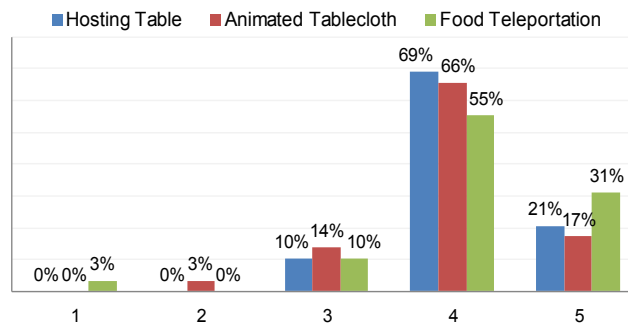
Figure 5.21: Feedback of each interaction module on increased engagement.

- *Statement 3: Tangible interactions can enhance the sense of "being together".*

One design goal was to enhance the sense of "being together" even if users fail to share the same physical space, by highlighting the tangible interactions around food. As verified in Figure 5.22, compared with virtual interactions through digital graphics, tangible interactions involving diversified sensory channels would foster intensified feeling about the presence of remote people.

Co-Presence Feeling
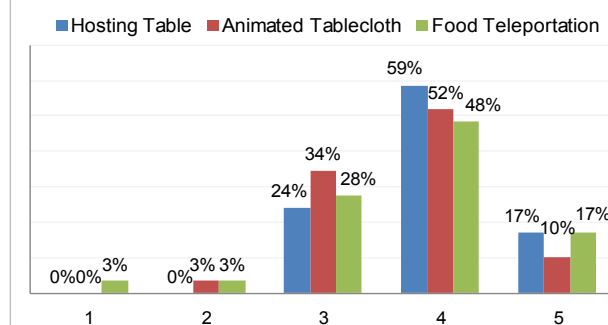
Figure 5.22: Feedback of each interaction module towards sense of "being together" via tangible interactions.

Repeated-measure ANOVA showed a significant difference among the three modules, $F(2,56) = 4.874$, $p = 0.011$, indicating that each activity module

contributed differently to the overall presence experience, Hosting Table

contributed most to the presence experience. All the three interaction modules

are significantly associated with the overall experience (Pearson's r > 0.7, $p <$

0.01), and Hosting Table has the highest coefficient (Pearson's r = 0.855, $p <$

0.01), suggesting that it may play a more important role in determining the

overall presence feeling of CoDine.

5.6.2.5 Interaction Screen

These three interaction modules are connected with and controlled by the

Interaction Screen, which uses the Kinect to achieve the gesture-based icon

selection. Users move their hands towards the screen to choose different icons

on the screen to initiate corresponding interaction module on the other side. I

assumed gesture selection could be more intuitive, convenient than a keyboard,

mouse or button, and also increase the playfulness during dinner.
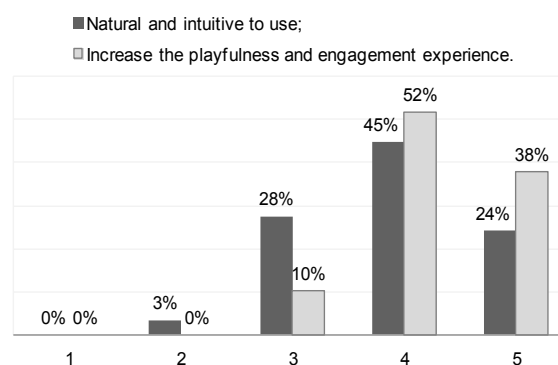
Figure 5.23: Feedback of Interaction Screen on intuitiveness and playfulness.

From the feedback (Figure 5.23), a majority of the users agreed with the natural interaction (45% rated "Agree" and 24% rated "Strongly Agree"). For the rest, one potential reason would be their failures to activate the system after a few trials, since they did not strictly follow the directions of the right gesture. To select one icon on the screen, user needs to push straightly towards the Kinect, so if just push freely, the icon can't be selected. Noticing this, I think it is necessary to refine the Kinect tracking method, making it more flexible. As for the playfulness, 52% rated "Agree" and 38% rated "Strongly Agree", and none rated "Disagree", indicating the increased playfulness and engagement using this gesture interaction.

5.6.3 Study Summary

This preliminary study provides a snapshot into users' perception of the CoDine prototype. They reported to have dinner together with remote families once a week, mainly relying on video call tools like Skype. Although these tools could easily build the connection to enable exchange of information, people may not feel emotionally connected and involved, for the lack of interactive activities to support the shared eating experience. Therefore, this prototype attempts to enrich the traditional co-located shared eating using interactive technologies.

Users' overall reactions about the prototype were quite positive. They found it provided additional interaction, enjoyment, and expression. As one user reported, *"I am really surprised when the bowl begins moving towards me, and I can imagine its powerful expression if I conduct this to my Mum at home"*. Similarly, another user mentioned, *"It was really great to see the words actually been printed out on a piece of bread, and I am sure my Mum would be happy to receive it*."

Besides Likert rating, I also included an open-ended question at the end to ask for suggestions on how to improve the system design. One user mentioned the role of smell during eating, so it would be good to have smell generators within the system, to enable the sharing of food's aroma. Another user suggested using part of the screen for movie or TV program, because watching TV together while dining is also a shared routine activity for most families. These suggestions are compatible with my design rationale, indicating the necessity of shared activities and sensory experience in mediating communication. All these would be very helpful for the design for co-dining experience, especially of triggering more emotional connection and cultural recollection to support remote communication.

Through this evaluation, I acquired valuable feedback about the system effectiveness, and how users feel about the dining experience. The results verified the proposed approach of technological mediation, which involves multiple interactive dinner activities to enrich communication.

5.7 Discussion

Media technology plays a big role in changing the way people socially communicate with each other. This case applied several digital technologies to enhance food-based social interactions. CoDine enriches the mealtime communication through interactive and physical dining activities to create the co-dining experience for remote people, putting together the social, cultural and communicative roles of food.

As one case towards "Food Media", this prototype utilized interactive activities to reconstruct the missing physical and multi-sensory experience of food in remote dining. It connects people situated in different places while eating food, and also brings together a variety of interaction ways that neither traditional, face-to-face, geographically co-located groups nor commonly used communication tools could achieve. The prototype supports multiple interaction modalities around food to afford the engaging social interactions: Hosting Table to remotely move the partner's dishes; Animated Tablecloth to

display expressional picture on fabric; and Food Teleportation to teleport a digital message using real edible food. All these interactions are integrated seamlessly into the telepresent dining scenario and achieved through natural hand gesture in front of the screen.

The design and development of CoDine highlights three main aspects for enriched communication around food: physicality, related activities and situated cultural association, which provide implications for relevant research.

First, mediated communication should go beyond information transmission to enhance the sense of social togetherness for remote individuals. From the prototyping and study, I observed interaction through connected physical objects could enhance the senses of "being together" in remote dining, compared with interactions that only rely on digital representation.

Second, interactive activities people used to conduct around food in collocated context could serve as springboard to be examined and extended into remote situations in a shared manner. As observed in the study, people felt more engaged in the dining communication through designed activities, compared with video chatting. One possible reason is that activities could keep the communication going by use of human motion, not just words and sounds.

Third, I propose that one must consider the social structure and cultural background of users to inform the design of a technological intervention of food. Internal and emotional values of the communication context could be taken into consideration to make the experience impressive and sustaining. Dining is a process more than seeing and talking to each other, it's also a situation when people show love and care to others, and recall good memories related to food. Utilizing technology to maintain or simulate such social rituals (such as food serving) is likely to be appreciated by people.

In this context, food becomes a valuable asset in the mediated communication. At the same time, users become engaged into this playful and natural interaction over food and eating. Although never intended to replace real physical co-located dining, I believe this system would be very beneficial for the time when routine family dinner or scheduled friends meal is not available. CoDine is not only expected to facilitate people's communications for keeping relationships closely and the sharing of their eating experiences, but also to sustain and enrich communication between remote people with more emotional communication experience.

Chapter 6

Food Messaging

6.1 Overview

One of the main forms of digital communication is text messaging. Based on

the comprehensive analysis of food in Chapter 2, I envisioned food can be

digitally enhanced as a multi-sensory carrier of social message. Besides

activity-based, food could convey implicit messages through multiple non-

verbal but sensory modalities such as shape, color, smell and taste, as well as

associated cultural meanings.

It is not unusual for people to use food to convey messages. Examples include

the frosted words piped on birthday cakes and chocolates, letters carved into

cookies, fortune cookies with surprise messages inside, and logos or ads

painted onto food for business promotion. However, due to the special skills

required to make such decorated food, using edible media for daily

communication has not yet been widely adopted.

Advances in personal fabrication and food printing technology make it much

easier to embed personalized messages in the food we eat [19]. With rapidly

reduced costs in hardware, food printers have become increasingly affordable and practical for consumer use. They may even enter the kitchens of many households as an ordinary home appliance in the near future.

This chapter presents another envisioned form of social communication digitally mediated by food, which I defined as food messaging, i.e. expressing digital messages in edible format via food printing. Words are not delivered digitally or on paper; instead, they are impressed in or decorated on edible products. To send a food message, users can simply enter the content of the message on any digital device and specify how they want this message to be printed on a piece of food. The message can then be sent to either a third party food service for processing and delivery to the recipient or simply to the food printer installed in the recipient's home or office. Probably the integration of digital message sending and edible message representation could lead to new possibilities that go beyond digital or edible communication all by itself. As mentioned by Richard Harper, "combining existing communication technologies can encourage novel forms of expression" [75].

Although food printers are getting available in research and commercial areas, all of them are for fabrication purposes and do not come with functions for mobile messaging remotely. I will describe the detailed development of

Foodie prototype (Figure 6.1). It broadens the Food Teleportation module out of the remote dining context, and enables a new style of messaging via mobile-controlled food printing. With this new communication method, I conducted exploratory interviews to obtain an initial sense of people's opinions of food messaging, in comparison with current paper and digital media. The results suggested the viability of food messaging, and also pointed out the potentials of food to convey richer meanings beyond words. So I carried out a survey analysis into the perceived expressiveness of certain food ingredients, to understand whether and how food could provide different messaging experience.
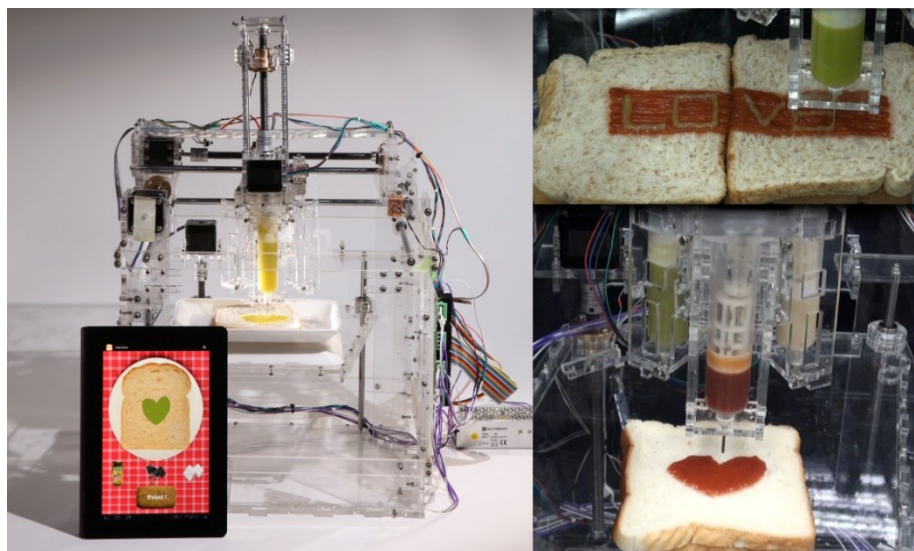
Figure 6.1: Overview of Food Messaging prototype: *Foodie*.

6.2 Background

With a variety of mobile devices available today, especially the smart phones, we are able to send and receive messages in various formats from virtually anywhere and anytime. Yet, the types of messages we can create and send with these devices may not support the personal closeness, intimacy, or care that could be felt while exchanging handwritten letters or postcards in person. For example, a card from someone is charged with the efforts the sender goes through to choose the image and craft the sentences that represent the sender's feeling towards the recipient [41]. Both the content and the form of the message can reflect the situation of the person, and offer the receiver a concrete and contextual message.

Customization is another significant aspect of interactive media. The technological ability to provide content tailored to individualized user interests and to treat each user as an inimitable individual forms the crux of customization [94]. To the extent the user is able to see his or her own self in the interface and/or the content generated via that interface, it leads to a satisfying interaction [94]. The sensory richness offered by various values of the modality variable offers a richer manifestation for the user. In this research, I adopted this term to imply not the unique displayed aspects but the medium's ability to offer customizable features that can represent individual's expression.

Considering content, form, and customization of messages, I proposed food

messaging, trying to achieve both meaningful and emotional expressions

through food. Although food has been used to deliver certain expressions in

tradition, such as congratulations, wishes and greetings, it does not come with

explicit and customized messages. On the other hand, printing on food has

emerged as an innovative way to fabricate edible goods and market a product,

but not for social communication yet. In response, I aim to augment current

social messaging practices, leveraging on the potentials of food itself. I have

developed a functional prototype *Foodie* for sending and receiving messages

by means of food printing. *Foodie* system aims to support personalized social

communication through the customized composition and delivery of food over

a distance.

6.3 System Description

6.3.1 Overview

To achieve the design, transmission and reproduction of edible messages, the

system consists of the message design interface on a mobile device for

message input and the food printer (used in CoDine for Food Teleportation)

for crafting the food message. In between, data from the mobile device is

transmitted to the remote server via an Internet connection, and the server is

connected wirelessly with the mechanism's master board through Bluetooth (Figure 6.2). Through the wireless communication between the mobile device and food printer, users can composed patterns and messages freely and send them to the mechanism in a remote location. Then the crafting is conducted in 3 dimensions with multiple types of edible materials, through a layer-by-layer printing process to achieve the physical reproduction of digital content. Messages can therefore be designed and delivered remotely, serves as a novel way for social catch-up over a distance.
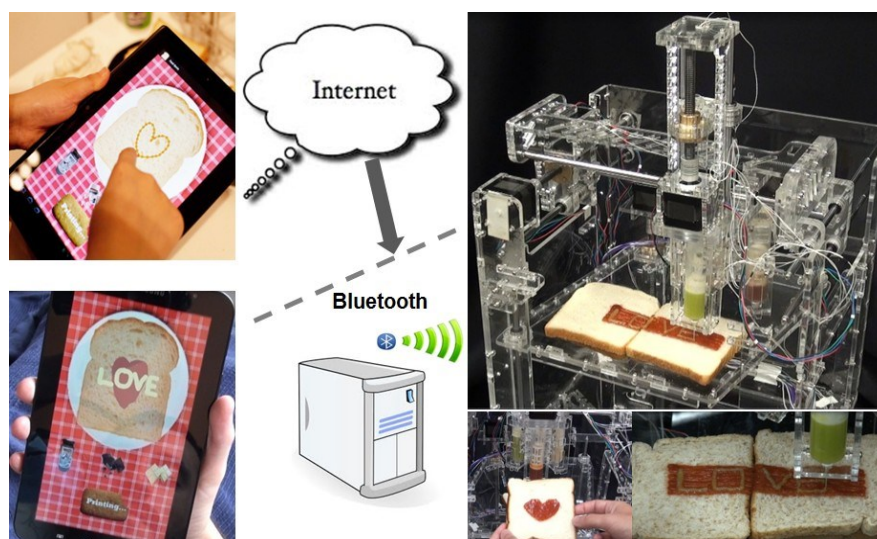
Figure 6.2: System configuration of Foodie: Message Design Interface and Food Printer.

6.3.2 *Message Design Interface*

Regarding the Message Design Interface, I considered two typical ways: one is selecting elementary patterns from a predefined toolbar, which may include

simple shapes, symbols and letters; the other is to follow user's free design of drawing and writing. In comparison, I desired to encourage free-form design from users, with the intent to increase creativity and social engagement. At the same time, I tried to make the design interface and creation process intuitive, without prior knowledge of design tools such as CAD. On the other hand, food in real life is never something rigid; it is always with changeable shapes and textures. Additionally, the feature of handwritten would contribute to the sense of care for the receiver by adding the customizability element. These considerations led me to the freely composed message for more intuitive and personalized communication.

I developed the Message Design Interface as a mobile application that users can easily install in mobile devices. The current version works for devices with a touch screen and Android system. On the touchscreen, users can select different food ingredients using a set of icons. They can create messages or images by scrawling and writing on the screen using finger, and change the shape, color, and taste by tapping on different food icons during the design. The application can capture the pattern, and send it to the remote terminal to be reconstructed with food ingredients.

Line-detection Algorithm

As a user writes or sketches on the mobile touch screen, his/her finger movements are tracked in real time, and then the detected design is divided into a series of segments. As shown in Figure 6.3, left pattern is user's original drawing, and the right one shows segmented dots of processing. Each line segment would be tagged based on its direction and length. Pressing the Print button transmits the identified segments' data to the food printer's master board, indicating the robotic carriage and food deposit's movement routes.

Figure 6.3: (L) Screenshot of pattern tracking and segmentation, before and after "Print" is pressed (R) User use this interface to draw a "Heart".

At this stage, I assumed user's input can be analyzed as a series of continuous curves, and each curve is a set of continuous points. The main objective of the application is to detect, process, and then reproduce the pattern with continuous strokes following user's original drawing. Therefore, the algorithm should be able to produce recognition results of curves as accurate as possible.

The partition is done according to chord-arc length algorithm [139]. I applied a piece-wise line detection algorithm (PLDA) based on classical Hough Transform and Segment Hough Transform [103], which produces acceptable results in terms of runtime and detection rate for both straight lines and curves. Each curve segment would then be approximated to a line stroke based on the slope sampling matching with 16-connectivity chain code [5] and tagged with its direction and length. The detailed procedures are as follows:

Step 1: Divide each continuous line into approximated segments such that each can be treated as a straight line. Store two endpoints of each segment.

Step 2: Tag each line segment with 16-connectivity chain code.

Step 3: Slope sampling matching. With the assigned slope value and position of the first endpoint of a segment, I can reconstruct the original line.

During the development, I experimented with different values of segmentation threshold. With smaller threshold, curves are divided into shorter segments, resulting in the increased number of approximated points. There is an obvious growth in pixel detection rate but a smaller pixel false alarm rate, which indicates the decreased percentage of incorrectly detected portion among all the pixels from the detected pattern.

Using this segmentation and reconstruction approach, I can transform the digital drawing to physical crafting and enable free-form design by users, rather than simply selecting or composing patterns from limited collection of predefined elementary shapes or characters. Although the current capability of algorithm can't handle complicated patterns, nor advanced functions like copy &paste, this self-creational feature can encourage creativity, in the sense that people would be motivated to create and send playful and inventive social patterns using *Foodie*.

Integrated with the food printer mechanism I developed, *Foodie* allows people to creatively compose a unique social message in digital format through a free-form drawing process, then deliver and transform it into real edible food. For example, a lady could draw a heart pattern on her mobile phone and send it to her boyfriend, which would be reproduced using food in his kitchen. Sending customized edible messages allows more engagement in the creation and experimentation than in the digital format. This system can be regarded as a tangible and expressive extension of the digital messaging practice, promoting remote interaction with multisensory experience.

6.3.3 System Testing

I carried out experiments to improve Foodie's overall performance, in terms of printing continuity, accuracy, resolution and speed. In building the mechanism, I had to consider a range of issues. For the mechanical design, I experimented with the diameter of syringe pinhead, coordinate speed of the 3-axis moving motors with piston pushing motor, and the distance between food platform and food droplet, etc. I also had to consider the characteristics of the food ingredient to achieve accurate crafting, for example the viscosity and density of different foods at different temperatures.
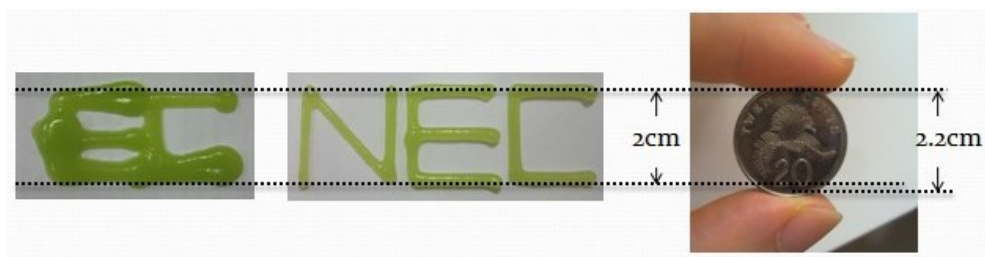
Figure 6.4: (L) Motor's speed not matched well, lower resolution; (R) Improved resolution achieved through matched moving speed.

Figure 6.5: (Top) Syringe rotation implemented to print with multiple materials; (Bottom) Print with single material.

I conducted many experiments iteratively to identify the suitable food materials, matched with different sizes of syringe pinhead. For this prototype, I experimented with several food materials to improve the accuracy and resolution, without sacrificing the crafting speed. Some of them need to be heat up and melt down, and some can be used directly. I finally chose kaya sauce to fine-tune these parameters, for its suitable fluidity and viscosity without heating.

With the finalized mechanical parameters, the mechanism crafts with the speed of 5mm/s - 7.2mm/s, taking about 3 minutes to craft the "LOVE" message, and achieves a resolution of 1-2 mm. Figure 6.4 and Figure 6.5 present some of the results during the adjusting process. I then implemented multiple-layer printing with changed materials, and composed the heart-shape image using ketchup. I have also experimented with melted chocolate, which achieved higher resolution for food crafting, but have not attached the heating feature to the syringe yet.

The development of food printer lowers the barrier to make or decorate food with lettering, and the combination with digital messaging transforms it into a new style for communication. Messaging through food demonstrates a subtlety and courtesy that messaging through digital devices sometimes lacks. By

spending efforts to send social touch messages and other general expressions of affection via food, people actually involve themselves into the creative and customized construction of message content and form. To understand further how such messaging could offer new communication experience, it is very important to investigate users' responses and perceptions.

6.4 Study 1: Explore Design Space

Unlike other communication media (such as paper or electronics), food messaging allows recipients to not only see and touch messages, but also to smell and taste them. Inclusion of other senses adds additional expressive power to language, providing an added sense of reality that results in deeper interpretation and reflection on emotion [13]. Sensory stimulation by food messaging extends the communicative richness of information and can enhance the social bonds between parties involved in the communication.

While message on food is already used for some specific cases (e.g., birthday cakes with a greeting message), it has thus far been quite overlooked by research. Yet, this new way to communicate raises some important questions, not only about food itself, but also about communication between people. Questions about the viability of food messaging, its effects, its uniqueness, and scenarios of use remain to be answered. More specific questions include:

would food messaging be acceptable for social communication? If yes, in what ways would people prefer to use it? And how specific properties of food contribute to the communication? Would this method trigger emotional attachment or engagement? I carried out an interview study to investigate people's responses, preferences and interpersonal understanding towards food messaging as compared with existing approaches.

6.4.1 Study Design

Traditionally, people use paper (i.e., letters, notes, and cards) to deliver social messages. More recently, we shift some of this load to digital devices such as computers, mobile phones, and tablets, which have led to natively digital forms of communication such as status updates and wall posts. However, there are still occasions where paper is preferred as a message medium – perhaps because of the aesthetic qualities of fine paper, or meaningful additional costs required for creating and delivering physical messages. So I wanted to understand when and why people might use food messaging compared with these two well-established forms, and how much these practices might vary across different cultures.

As the meaning of experience can only be accessed through the interpretations that users make themselves, as the first study, I adopted interviews to access

the wider context of people's lives, which is one of the best ways to learn about the user's experience [14].

Twelve volunteers (5 male, 7 female) aged from 24 to 38 (M=27.6, SD=4.1) were recruited from the university community. Among them, five were students attending the departments of engineering, computer science, and design, and seven were university administrative staff. They represented diverse cultural backgrounds, coming from 11 different countries in Asia, Europe, and North America. All participants were familiar with paper and digital messages. When discussing messages using food, they only mentioned the experiences of words on birthday or wedding cakes.

To enhance participants' understanding of food messaging before they were asked about its potential uses, interviews began with the demonstration of a sample message printed using the developed prototype (Figure 6.1). The interview was then conducted as a series of face-to-face, semi-structured interviews, each last around 40 minutes. Participants were then asked to describe their personal experiences using digital media, paper, and food for social communication, as well as their thoughts on how they might use food messaging in the future.

I used a three-phase semi-structured interview process: (1) Clarify the definition for "Social Messages", present examples of social messages on paper (letter, card, note, etc), digital (SMS, IM, etc), and existing food messages (messages made into cake, candy, cookie, jelly, etc); (2) Introduce my personalized food messaging idea, together with a narrative scenario (preparing breakfast for loved one with sweet words), then demonstrate the prototype device to further explain it; (3) Discuss to compare paper, digital and food media, and share opinions in the context relating to their experience with each social medium. The key prompt was "Please describe in what kind of scenarios you would prefer to choose paper/digital/food for social messages, and why in this scenario," with media types' order randomized.

Interviews allowed individuals to recall and explore their personal experiences and thoughts on using different media for messaging. This also allowed us to gauge expectations and accepted norms regarding the use of food for social messaging. During the interview, participants were encouraged to describe different aspects of using each medium, like what relationship, content, occasion, and types of message, etc. The real life examples and anticipated scenarios were used to gather information about the differences of how people viewed food messaging compared with the other two. Although the developed

prototype was demonstrated, I asked the participants not to be limited by the current capabilities of it. Rather, I wanted them to engage with the underlying design concept.

6.4.2 Findings

Interviews were audio recorded and transcribed verbatim. Two researchers performed open coding, after which their results were compared and refined to achieve consistency. Analysis of transcripts revealed several key themes across the open codes, which represented distinct topics regarding current and prospective food messaging patterns, and led to a deeper understanding of people's motivation, practices and choices of each medium.

I broadly anticipated the increasing cost of digital, paper, and food to result in decreasing frequencies of use. From the questionnaire, I found that participants used digital devices constantly, paper infrequently, and food most rarely of all currently – only a few mentioned using foods to send social messages, like decorating a personalized cake. I also anticipated food to have much stronger emotional valence due to its characteristic. Based on participants' subjective experiences, together with the reasons behind such scenarios, I confirmed these broad expectations: "*Food makes more sense; it's*

more personal and gives happy and warm feelings" (P2). I discuss several key

dimensions that capture potential variations in food messaging practices below.

6.4.2.1 Communicating Emotions vs. Emotional Communication

Digital messages were mostly described as "*cold and virtual*" (10/12). Paper

messages were described as being more emotional because paper can be

touched and felt, creating a stronger impression and a stronger sense of

sentiment. Paper can also be preserved as a memento for a long time: "*Paper*

needs a longer time to reach the receiver, but it can be kept for longer…you

can feel it, and you can do a lot with paper" (P3). Food was described as the

most impressive and special because people not only touch and feel it, but

consume it into their bodies: "*It becomes part of your body*" (P12). This

naturally has a visceral and biological impact on people's emotions. Food was

therefore preferred for providing rich and subtle communication as well as

inspiring strong emotions such as happiness, affection and disgust (as in [72]).

Messaging through food demonstrates a subtlety and courtesy that messages

through paper and digital lack. The messages sent via food are typically short

and emotional. Examples reported by participants include "*Happy Birthday*",

"*I Love You*", "*Be Happy*", "*Thank You*", "*Get Well Soon*", "*I Miss You*",

"*Good Luck*", and so on – typically routine and social touch messages. While

generally positive, another potential use of food message is making-up: "*Even after a fight, we can say sorry using* food messaging... *it seems easier to be touched*" (P5).

In contrast, the suggested use of invitations, such as *"Curry Night Saturday, my place"* (P8) printed in curry sauce on a plate of rice, does not in itself communicate an emotion. However, it does communicate a neutral message (an invitation) in a vivid way. Whereas communicating emotions with words could transcend cultural differences through the appropriate use of language, emotional communication via food has the risk of being specific to a particular culture or interpersonal history. This suggests the need for further empirical work investigating the cultural generality of food-emotion associations.

6.4.2.2 Special Occasions vs. Special Relationships

Participants saw these three types of media as suitable in different contexts. Digital messages are used "*almost for everything, anytime and anywhere*" (P4), while paper messages are used for more serious and formal occasions, such as to "*express gratitude and show respect to my parents or boss*" (P8).

Food, on the other hand, was perceived as "*something more special and personal*" than either digital or paper media; therefore, it should be "*only prepared for someone you really care*" (P2) and "*delivered in special*

occasions" as *"it need some reasons to spend the extra resource and effort* (P4). Many participants believed food messaging is only suitable for close ties, and they might not feel comfortable receiving food messages from an unfamiliar person: *"it would be weird if I received a food message from a stranger"* (P1).

The special occasions, such as birthdays, weddings and celebrations, are typically of the pleasant and casual variety. One participant explained, *"It's at happy occasions that people share and enjoy food. When feeling sad, people don't feel like eating"* (P1). The positive associations and connotations of food have also been highlighted through questionnaire-based research by Armand Cardello, who commented "Not only did foods elicit a variety of emotions to varying degrees, but these emotions were generally positive" [27].

The giving of food can also spark recollections of special moments in special relationships: *"Food naturally makes people happy, and reminds of happy moments; it would contradict with the meaning of food if you used unsavory food to express negative feelings"* (P3). Another example is traditional home-made recipes that bring back past memories, places, or people: *"After my mum passed away, my aunt usually cooks dish especially for me in my mum's style, she knows I miss her so much and always tries to make me feel better"* (P9).

There is a strong relationship between memory and the emotional dimension of food. Given that food is an element of the material world that embodies and organizes our relationship with the past in socially significant ways, the relationship between food preferences and memory may be regarded as symbiotic. Memory is embodied, often recalled via the sensations of taste and smell [109].

6.4.2.3 Symbolic Investment vs. Cultural Symbolism

Although digital messages are fast and convenient, they are very common and easy to replicate at almost zero cost, making them perceived to have "*the lightest value*", as "*you rarely feel something when reading a message on the screen*" (P2). Paper offers moderate value: "*paper is a little heavier*" (P5). And food messages have the highest perceived value arising from the special effort required.

The material, time and thoughts cost of crafting a food message is a symbolic investment in the relationship with the recipient: "*when I receive a birthday card from my friends, I feel much happier and warmer than a 'Happy Birthday' through SMS or Facebook, especially if the card was designed by themselves with handwritten words and drawings. This feeling would be more intense if the message is in food, because you can feel your importance for*

them to spend the effort. It's customized and special, I would really appreciate

that" (P5). It is an *act of service* [77] - doing special things for people you

love and care.

However, it is not just the act, but the content of a food message that plays a

symbolic role in communication: *"food entails richer meanings, represented*

not only by appearance, but also typical smell and taste, indicating additional

feelings" (P3). This can arise as a universal convention – *"food has a wide*

range of tastes, and all these tastes … can be a universal thing across all

nationalities" (P8) – as well as something unique to a culture – *"Red eggs on*

baby's full moon mean good fortune, completeness and a new beginning, and

the cakes, called Ang ku kueh, are shaped like the shell of a turtle or round to

symbolize longevity" (P8). This resonates with the claim that every country has

its own type of food and the preparation of such food impacts that culture [12].

For example: pumpkins at Halloween in the United States, turkeys for

Thanksgiving, and dumplings during the Chinese New Year.

Ultimately, the symbolic investment in food message is likely to be

appreciated if it conforms to prevailing cultural norms regarding appropriate

symbolic communication, with implications for the interpretation of both the

emotional content of the food message and the value placed on the interpersonal relationship.

6.4.3 Study Summary

This study compared the preferred usage situations for social messaging with digital, paper, and food medium. The findings, which double as considerations for design, cluster around the different ways in which food represents an emotive medium for special instances of symbolic communication. This verified the proposed methodologies of utilizing food's multimodality to provide rich communication experience, and also helped to understand the when and why food messaging could symbolically communicate emotions and other concepts.

Generally, people welcome the idea of food messaging; it was perceived as an interesting and impressive form of communication. People felt more connected and engaged in the sending and receiving of messages made of food, as compared with other forms of messaging. They believe it can help to enhance social relationships and is especially useful to express thankfulness, gratitude, good wishes, love, and good feelings. Food is preferred for providing richer and subtle communication, which typically triggers stronger emotional effects like sense of warmth, efforts and care. On the other hand,

due to the cost and effort required, people believe food message should only be used for close relationships and special occasions. It is usually personalized to trigger special meanings and memories among intimate people. They seem less willing to accept it from unfamiliar friends. From the study, I can see that while food sustains physical bodies, it can also form the basis for conveying implicit and subtle meanings associated with food.

Therefore, the self-reported interview data explored food messaging's uniqueness and viability with other media, and also pointed out the necessity to investigate the empirical food-meanings associations, which would help to reveal how well food could symbolically communicate emotions and other concepts. I conducted a second user study to address this question in depth.

6.5 Study 2: Understand Food Social Language

As discussed, food always comes with rich meanings based on its multimodality. The meaning of a food message can come from both the spatial configuration of food ingredients (e.g., words, symbols, or pictures), and the meanings those ingredients hold for the creator and the recipient of the message. For example, a message in sweet ingredients evokes sensory pleasure that can be metaphorically mapped [99] by both sender and recipient to the "sweetness" of their relationship.

In Study 1, I obtained some conventional usages. Most participants suggested using food ingredients to communicate emotions such as happiness (e.g., using sweet ingredients with bright colors, like strawberry jam) as well as on special occasions following traditional customs (e.g., chocolate on Valentine's Day, moon cake for Chinese mid-autumn festival, pumpkin for Halloween), while foods considered as bitter, disliked or strange are more for negative feelings, although would be rarely used. They also mentioned some typical foods that have common meanings across a wide population, such as chocolate for love, cake for birthday and champagne for celebration, all of which provide a practical basis for using food to transmit added information beyond the text.

Within this general trend, each user's specific choice actually varies, depending heavily on their personal food preferences, their knowledge of receiver's preferences and cultural backgrounds. For example, sending a message using chili sauce could excite someone who loves spicy food and disappoint someone who doesn't, but the social effect depends on mutual inference of intentions and reactions, perhaps through a history of eating together. Therefore, an understanding of taste preferences between sender and receiver is a prerequisite for conveying implicit meaning via a food message.

However, still relatively little is known about whether people would rely on the multi-sensory experience with food to convey rich social meanings, and more specifically, the individual preferences and practices in choosing suitable ingredients to convey intended effects using *food messaging*. Previous theories on the semiotics of food are not specific to food messaging, and more research is required to understand how food messaging can combine both symbolic and literal (e.g., text) communication. I therefore conducted a survey involving a wider audience to further examine the relationships between food printing, ingredients and associated meanings specifically for food messaging:

- **Food printing to ingredients.** What printable ingredients would people prefer to use for food messaging?

- **Ingredient to meanings.** What meanings are associated with the suggested food ingredients, and how do attributes of ingredients influence their interpretation?

- **Meaning to ingredients.** What ranges of ingredients are commonly associated with suggested meanings?

6.5.1 Study Design

I collected data using Amazon's Mechanical Turk service [11], a popular

crowdsourcing Internet marketplace. I published one survey-type task with

multiple assignments on the website, so that one worker can't do the task

multiple times, allowing me to get responses from a wider audience. In the

task, I included an introduction to personalized food messaging and the *Foodie*

prototype. Each worker was asked to propose three different food ingredients

that they thought were most compatible with the described technical and

communicative requirements. Specifically, proposed ingredients should have

or can be made into thick-fluid texture required by the current prototype.

Figure 6.6: Screenshot from online task on Mechanical Turk.

For each proposed ingredient, they provided three terms to describe its

associated social and conceptual meanings, and selected one food attribute that

represents the main reason for using that term, i.e., based on the color, taste,

smell, culture, texture, or temperature (Figure 6.6). After completing three

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[11] Amazon Mechanical Turk: https://www.mturk.com/mturk/welcome.

ingredients, workers filled in their demographic information and submitted the task. After that, the researcher either rejected the work or approved and paid for it. The payment for completing this task was set as 0.1 USD.

6.5.2 Participant

I collected data from 154 respondents (68 males, 82 females, 4 did not indicate). Most were ages 21 to 30, mainly from India (53%) and the US (27%). Other nationalities included Chinese, Mexican, Italian, Canadian, and Singaporean. Among them, 54% used English as a first language. Respondents' professions included teacher, student, housewife, manager, artist, typist, architect, farmer, journalist, nurse, IT, and business. 21% had jobs related to food, and most didn't have dietary preference. They spent an average of about 6 minutes on the task.

6.5.3 Study Results

I now look into the three relationships based on the collected data. I analyzed the data from several angles: the conventionalized mappings from ingredient to expression and vice versa. I used content analysis that involves categorizing the data and then studying the frequency of category occurrences [156].

6.5.3.1 What printable ingredients would people prefer to use for food messaging?

Respondents proposed 438 ingredient entries in the raw data. I grouped them into 68 types of ingredients, merging the same terms and also similar ingredients with different names (e.g., ketchup and tomato sauce). The top five ingredients by proportion were chocolate (15%), tomato (11%), strawberry (10%), cream (9%), and chili (5%). The next eight were vanilla, peanut, mango, salad dressing, butter, cheese, honey, and mustard.

I found dessert-related ingredients to be one of the main categories among all foods (43%). Other categories included fruits (25%), vegetables (16%), and also culture-specific ingredients such as Chai (a mixture of aromatic Indian spices and herbs), Ghee (a special butter in South Asian rituals), and Laddu (ball-shaped sweets popular in South Asia). I see from this analysis that sweet food is a preferred type for food messages, but culture-specific ingredients could also play a vital role in supporting food-enriched social messaging.

6.5.3.2 What meanings are associated with the suggested food ingredients, and how do attributes of ingredients influence their interpretation?

There are 1344 terminology entries in the raw data. I first unified words with the same root (e.g., intimate and intimacy, happiness and happy), which resulted in 329 distinctive terms，and then calculated their frequency across the whole dataset, ranking them by frequency of occurrence. 28 top-mentioned

terms are visualized in Figure 6.7. The bigger a word appears, the more frequently it occurs. Other terms included attractive, tangy, bright, comfortable, exciting, angry, cold, good, like, care, and exotic.

Reviewing all the terms, I noticed more positive terms than negative, which supports the finding from Study 1 that food messaging is more preferred for positive feelings. These terms belong to various conceptual types, including emotional feelings, relationships, properties, and identities. This finding is in line with previous corpus analysis, which suggests that cues-laden words are largely used to indicate emotion or to disambiguate a message [153].

Figure 6.7: Visualization of popular terms[12].

I therefore categorized the terms into cognitive and emotional types. In previous work, King and Meiselman reported the results of a comprehensive study into the emotions triggered by various food products [92]. Based on their results, I further grouped the emotional terms into positive, negative, and neutral, which generates four distinct categories for all the terms. Overall

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[12] http://wordsift.com/visualize

occurrences are displayed in Figure 6.8 (L), and detailed in Figure 6.9. As shown, positive affect is the dominant category with 61%, followed by cognitive at 33%. These terms can potentially be explained with reference to metaphorical mappings between taste experiences and social relationships [99], as in the phrases "You're sweet", "Spicy relationship", and "Turned sour".
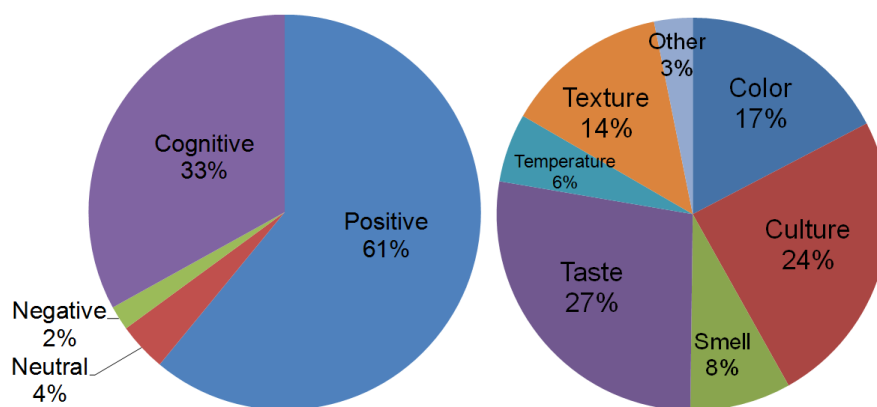
Figure 6.8: (L) Categorization and distribution of suggested terms (R) Overall distribution of reasons.

Food could transmit different types of messages through changing properties of itself, such as color, shape, even smell and taste as well. Literatures have examined the different effects of these sensory modalities. Of all the five senses, smell is particularly important because it is directly linked to the limbic system, which controls our feelings and memories [131]. Taste is often symbolic and it can help to accentuate a message and make it more stimulating [131]. In the study, besides interpretive terms, participants also indicated the main reason for using that term, based on the ingredient's color, texture, smell,

taste, or its cultural association, by choosing the most representative reason
from the list.
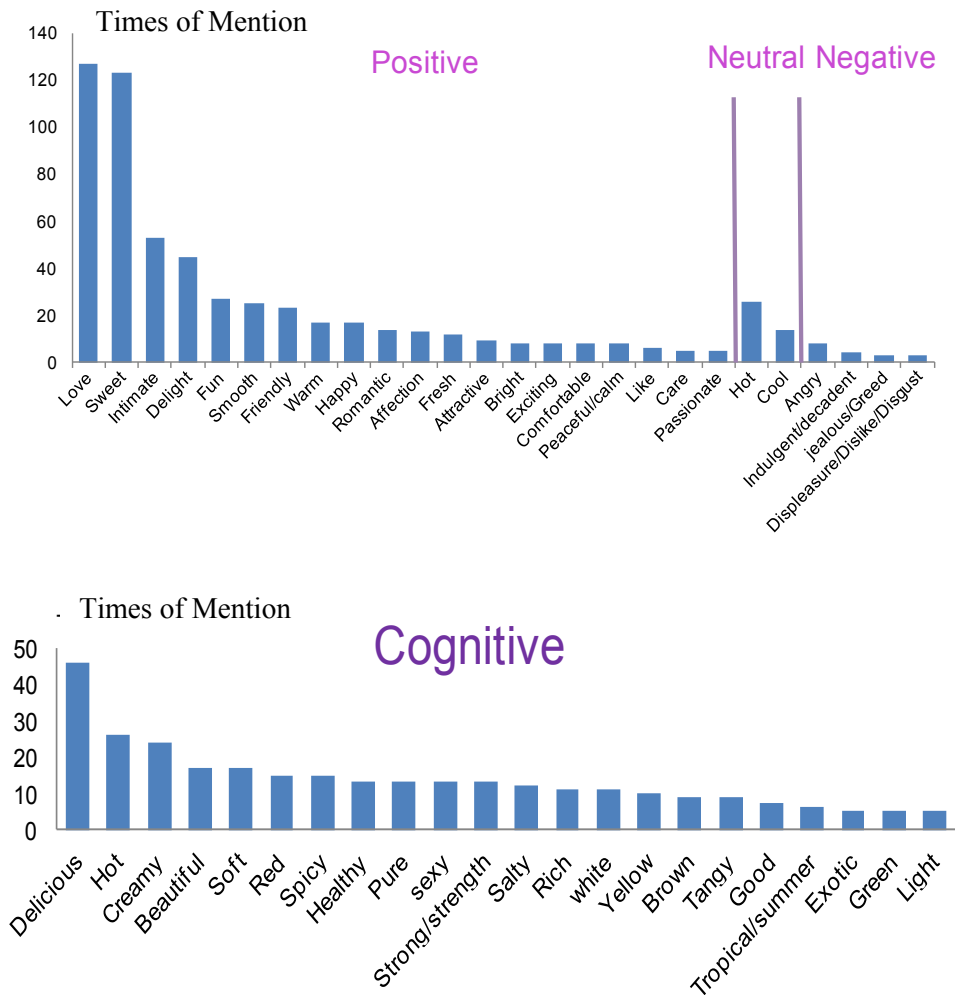
Figure 6.9: Detailed examples of Affective and Cognitive terms.

Figure 6.8 (R) reveals the distribution of reasons across the whole dataset. The
sensory properties, like visual, olfactory, and tactile qualities of food can have
a direct emotional impact [45] and they together make up around three
quarters of the reasons for selecting food-messaging ingredients. However, the
dominant category of taste (27%) is closely followed by culture (24%),

demonstrating that people's interpretations about food are affected by and interwoven with culture, both regional and global. For example, chocolate is considered as a representative of "Love" and "Romantic" over most of the world, while people from Asia may also perceive chocolate as "Exotic".

On the other hand, people from different cultural backgrounds may choose different ingredients to express "Love", perhaps strawberry, mango, pineapple, or honey. Meanings can also originate from food color, texture, smell, and temperature. In the study, respondents indicated "cheerful" for orange's color, "smooth" for cream's texture, "energetic" for lemon's smell, and "cool" for ice cream's temperature.

Although separated here, it is the combinations of attributes that determine the experience of consuming food and associated meanings, engaging all senses of taste, smell, touch (texture, temperature, and reaction, e.g., from hot spices), sight (aesthetic appeal), and sound (e.g., from biting and chewing) [97].

6.5.3.3 What ranges of ingredients are commonly associated with suggested meanings?

I then took a second round of analysis focusing on the three most mentioned terms, trying to figure out the pattern of how people relate different ingredients with terms in the use of food messaging. To build the connection

between these three terms and different ingredients, I created a table of related term versus ingredients, populating cells with frequency counts. Percentage of the total frequency count was used as a weight of the association between terms and ingredients. Figure 6.10 (L) shows how a large component of "love" comes from the cultural aspects of food ingredients, followed by color, taste and smell. This is an interesting point, indicating the significance of understanding the recipient's food culture when expressing "Love" via food.

Expression "Love" using food messaging was the most suggested term. The top four ingredients to communicate "Love" are chocolate, tomato, strawberry and cream (Figure 6.10 (R)). Among the four ingredients, their associations with "Love" arise from different attributes. For chocolate and cream, it is predominantly from culture (83% and 71%). For tomato, it is from the combination of culture and color (45% vs. 36%), while for strawberry, it is mostly from color (57%).
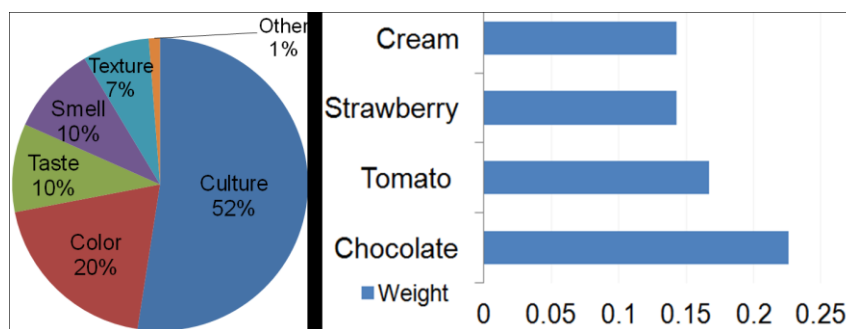
Figure 6.10: (L) Distribution of reasons for "Love" (R) Breakdown of ingredients for "Love".

I repeated this process for "Sweet" and "Intimate". Although their representative ingredients can be quite dispersed among participants, I noticed the difference in the influential factors for these terms. As shown in Figure 6.11, a great percentage (84%) of "Sweet" comes from the taste of foods, very small portion from smell, color, temperature, and culture, and none is from texture. From this, I could imply the close linkage of sweet flavor to emotion. Expressing "Intimate", on the other hand, most are based upon cultural perspectives of food, followed by the texture, taste, then smell and color.
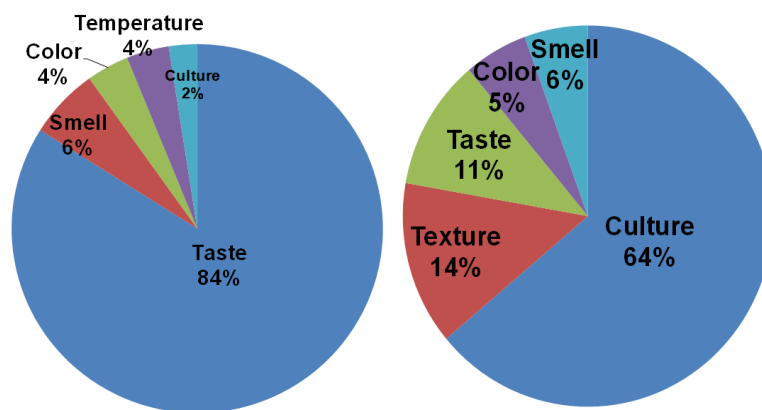
Figure 6.11: Distribution of reasons for (L) "Sweet" (R) "Intimate".

6.5.4 Study Summary

This study investigated the internal connections between *Foodie*, food ingredients, and linguistic terminology in the social context of messaging. My subsequent analysis verified the possibility of communicating richer meanings

through the unique properties of edible food, which can form the basis for enriched communication using food messaging.

Secondly, although food selection is highly personal, I noticed people preferred to use ingredients that are either popular across countries, like chocolate, or typical ingredients within a specific culture, e.g., most Indians suggested Ghee, as well as ingredients that are more for side dished or snacks rather than main dishes. These imply two main guidelines for the selection of ingredients to be included in Foodie system. Thirdly, the associated meanings are mostly related to positive emotions, supporting the results from Study 1.

On the other hand, there are exceptions to these general rules. For instance, chocolate means love and romantic generally, but it is considered as indulgent for some people. Chili represents excitement or anger, depending on the creator and recipient – as was reflected in Study 1, the specific selection and interpretation of an ingredient depends a lot on mutually understood preferences. In this sense, the social language of food is rather personal. Therefore, contextual ingredient selection can make messages more customized and hence more appreciated.

6.5.5 Discussion

Communication is the process through which we create or achieve shared meanings. Whatever definition or perspective of communication is privileged, food remains one of its most flexible and useful models [40]. The results of study 2 reveal a range of popular ingredients suitable for food messaging, and a myriad of expressions associated with them. In this section, I discuss how these results can help broaden and enrich social communication using *Foodie*.

Firstly, based on the consistent correlation between ingredients and social meanings, messages sent via food can be direct and straightforward, as with explicit words, but also indirect and potentially abstract – using images, symbols, and icons to make the communication provocative and stimulating. Food itself is also a message and the ability of particular foods to spark powerful personal recollections and associations (e.g., from family traditions, memories or cultural rituals) leads to another important aspect of food communication: using the symbolic meaning of certain ingredients or dishes to communicate in more personal and subtle ways.

Secondly, ingredients for food printers are not yet standardized and those available in practice depend on the ingredients stocked in the recipient's food printer. This tension suggests an additional stage of food-mediated communication – placing ingredients into the food printer as directed by the

message sender, in order to receive that message. The resulting sense of anticipation could play a role in creating "tantalizing" social interactions.

Thirdly, while food encompasses a rich combination of modalities, my results imply that culture and taste play relatively greater roles in transmitting added messages. I suggest they should be taken into account in future work on technologically mediated interactions around food, helping researchers and designers to accommodate the rich language of food in its use as a medium for social communication.

Just as Brown suggested, "A communication system needs to offer rich expression and allow users to interpret messages in their own way, rather than being limited to literal communication" [25]. Food reflects this as not only a medium to display message, but also a multisensory interface for implicit personal communication, in a way that each flavor can be translated into a corresponding emotional state or special experience from one's memory. Communication thus becomes deeper and stronger when all five senses are involved [131]. There is a possibility for us to promote diverse, human-scale, and multimodal forms of social messaging via edible food.

6.6 Discussion and Direction

These two studies investigated the design space of food messaging. The results are consistent regarding preferences for the communication of positive affect and the use of both global and regional symbolism. They are also complementary to each other: Study 1 looked into the high-level scenarios of food messaging, while Study 2 examined the low-level details of how different social meanings are associated with different ingredients. In this section, I discuss how these results can motivate other patterns of food communication and how food-mediated communication could evolve with progressively more sophisticated food printing techniques.

6.6.1 Beyond Social Messaging

Participants in the interviews were very optimistic about food messaging and I was inspired by the various applications they proposed. Foods deliver information, but also smell and taste experiences. To encourage healthy eating, messages like "Enough", "Less Wine", "Stop Eating" could rather be printed on food, resulting in a direct, powerful, but also playful intervention. Taking this idea to the extreme, food printers could also print progressively less tasty (or even bitter) food to curb eating. Alternatively, imagine printing cookies as letters or words to help children learn spelling and vocabulary. Food messaging systems could thus support learning while "playing with food".

They could also be used with older children to tell stories of family or local history, perhaps delivered as breakfast messages as part of a daily ritual.

Beyond personal communication, food messaging could also be used for public distribution. For example, weather broadcasting by printing weather images on people's breakfast, or declaring food-related rules in a friendly and funny way (e.g., chewing gum is forbidden in Singapore). Other uses include food advertisement and interactive food art.

In general, food messaging enables the physical customization of food to create and deliver personalized messages. This resonates with the hands-on attitude of "DIY" trend, and emphasizes physical interactions that can help people to feel more connected. As a platform for creative expression, food messaging allows people to artfully express aspects of their own creativity, building on the tradition of crafting highly personalized and memorable messages for special events.

Taking this even further, I can envision patterns for communication through food that will evolve with progressively more sophisticated techniques for food printing. For example, imagine delicate 3D modeling of a shape with a hidden message inside – fortune cookie style – which could rather appear

gradually as the food model is being consumed. Different parts of edible models could also be designed with different tastes (associated with different meanings), creating a cocktail or mixology-like approach to the design of food whose fusion of taste sensations and connotations transcends the raw ingredients.

6.6.2 Points to Ponder

Based on my studies, I point out several implications for food messaging design. First, digital media are unconstrained by time and space and can persist in many places, while physical paper is constrained by space but not time – it can persist in a place almost indefinitely. However, food is constrained by both space and time. A food message doesn't usually last long and typically has an ideal serving temperature, whether piping hot, ice cold, or somewhere in between. Food messages also require suitable places for food printing: people would mostly prefer to use it at home or other locations suitable for the consumption of food, like restaurants or hotels, but it certainly is not applicable everywhere. Furthermore, food messages can be risky and sensitive – a sender may offend the recipient if the selection of ingredients conflicts with the recipient's food preferences. I have learned that all food communication technology should ultimately be rooted in human culture.

6.7 Summary

Food is common in daily life, but special as a message medium. Foods are distinct because they are incorporated or taken into the body, thus they have physiological as well as psychological effects [108]. Food printing technique provides a new pathway to create edible messages. This case utilized food to enable an alternative messaging method, which focused on highlighting the physicality and a new communication language via food.

In this chapter, I introduced food messaging, and reported two studies that investigated people's intentions, perceptions and expectations of this new messaging approach. Food Messaging relied on food's sensory and emotional affordances to augment text messaging. The design of food messaging can be seen as combining both tangible and social forms of embodied interaction [49]: tangible food, when used as a form of social messaging, turns the action of sending messages into meaning that goes beyond any linguistic decoration.

In Study 1, I compared food messaging to conventional digital and paper messaging to understand when and why food messaging would be more appropriate as a form of social messaging. In Study 2, I investigated how different food ingredients could be used to communicate what the sender means through symbolic associations to understand the effect of food's multi-

sensory properties. Together, this understanding of the what, when, how, and why of food messaging will help both designers and end users to exploit the full potential of food-mediated communication.

Findings from the two studies indicated that food as a message medium encompasses both versatility and specialty. Food messages are distinctive compared with traditional paper and digital messages in that they support the expressions of emotions as well as emotional communication; help realize the special nature of occasions and relationships; and symbolize both efforts investments and cultural associations.

To sum up, food messaging is considered as a combination of both traditional food gifting and current digital messaging practices by technological intervention. Food as a message carrier enables explicit communication by employing food printed words, and also delivers implicit expressive meanings associated with the properties of food. Food messaging has the potential to become an important complementary channel of social messaging.

Chapter 7

Experimental Field Study

7.1 Overview

The exploratory interviews described in the previous section (Chapter 6, Study 1) provided an initial understanding into how food may potentially be applied and appreciated in social messaging. They seemed to suggest that food messaging could be a useful social communication method. However, traditional methods such as lab study cannot capture the true user experience in context [127], what people say may not parallel with what they do. I would like to further verify the findings and explore more dimensions of food messaging in a real world study.

The distinguishing feature of field study is that they are done in a natural setting with the aim of understanding what people do naturally and how systems or products mediated their activities. More specifically, they can be used to: (1) help identify opportunities for new technology; (2) establish the requirements for design; (3) facilitate the introduction of technology, or how to deploy existing technology in new contexts, and (4) evaluate technology

[156]. The main purpose is to see how this new messaging style gets deployed, and identify its opportunities based on the results of laboratory studies.

Concerning the potential issues of robustness, efficiency and operation complexity of my current Foodie prototype, I employed a commercially available Canon MG5320 edible printer in the exploratory field study to assess the potential effects of food-based interpersonal messaging. To investigate how people accept, use, and perceive food messaging, I conducted the study in an IT company over a period of four weeks. I analyzed the characteristics of the 904 collected messages from 343 senders as well as the survey responses and interview notes. The results suggested strong acceptance of food messaging as an alternative message channel, and highly reflected the results in Chapter 6. Further analysis implied that food message embodies characteristics of both text messaging and gifting. It is preferred in close relationships for its evocation of positive emotions. As the first field study on edible social messaging, the empirical findings provide valuable insights into the uniqueness of food as a message carrier and its capabilities to promote greater social bonding.

7.2 Evaluation Objectives

To envision the potential of food messaging, it is important to understand current messaging practices. Researchers have thoroughly investigated the use of popular text-based social message channels. Grinter et al. investigated teenagers' texting messaging practices in Europe, with emphasis on the linguistic character and content of communications [68,69]. Ling et al. [105] established a categorization of the uses of text messaging, stating the main uses are: coordination of events, questions, grooming, answers, commands/requests, information, personal news, invitations, jokes, thank you notes and apologies. Kopomaa [95] said that the main uses of SMS are for setting up meetings, exchanging gossips, giving info/reminders, and coordinating shared activities. Kasesniemi and Rautiainen [90] found that teenagers use text messaging to express emotions, to gossip, to express longing between peers, and to say things that they might not say in person, whereas, within a family group, they use text messaging for practical matters. SMS is also used within families to reinforce the family unit [25]. Chinese people used SMS for different purposes: showing care to family and close friends and sharing personal and emotional issues; coordinating daily event; exchanging and sharing information. Overall, about 58% of SMS messages were instrumental [110].

Although a pool of research has investigated the practice with digital media, we are not aware of existing studies that have looked into the possibilities of using an edible medium. It will be interesting to see if this new form of message medium fits into and further influences established social practices. Specifically, would it mainly be used for playful messaging, or might it also be used to provide information or commands/requests? Might it reveal new types of messaging that have not been previously used?

The goal was to investigate: how people accept, use, and perceive this new communication medium. I was concerned with: 1) whether or not people would use food messaging in a real social setting and what the typical scenarios could be; 2) what would motivate people to use this novel social messaging medium; and 3) how food messaging differs from conventional communication forms from users' perspectives and how daily communication could benefit from it.

To the best of my knowledge, this is the first empirical exploration of food messaging, and this field study is one of the first large-scale studies on this topic to be carried out in an actual corporate office setting. The findings would provide valuable insights into the uniqueness of food as a social messaging channel and its potential to strengthen social bonds.

7.3 Study Design

As for this new communication method, I think it is important to address the

first question of whether people would use it or not. I conducted the empirical

study to investigate this issue, focusing mainly on text messages.

The selection of the head base of a large IT company in China was pragmatic.

This company has a large pool of potential users who fits well with my

expected user group (young, technologically savvy users who are more willing

to try new things). The company's size also enabled me to test the application

in a variety of social relationships, and also users with different backgrounds

(e.g., engineers, staff, etc). Moreover, it was easier for me to keep track of the

large group of participants because they stayed in a centralized location. These

reasons make it a more appropriate study site than alternative candidates, such

as a university campus, restaurant or food court, or supermarket.

7.3.1   Food Messaging Service

I set up a simple food messaging service (Figure 7.1) in the IT Company. It

provided a website in HTML5 and PHP for users to enter text messages, as

well as the name and contact information of both sender and recipients (Figure

7.2). Because the study was carried out in China, I allowed both English and

Chinese as the input languages. As a basic service, message box includes a list of 25 common emoticons but does not support photos.

I have produced the *Foodie* prototype, which illustrates an example of a food messaging service in the future. This prototype is not appropriate for a field study concerning the limitations of robustness, efficiency, and operation complexity.
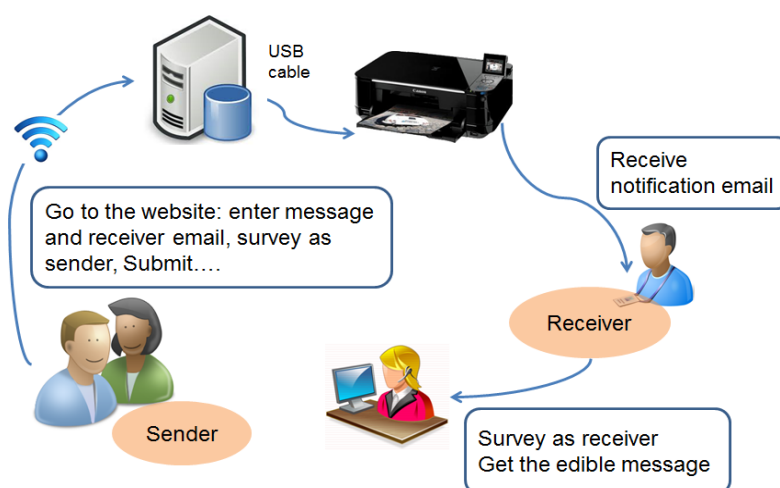
Figure 7.1: Overview of how to use food messaging service.

In this field study, I used a commercially available Edible printer kit[13] Canon MG5320 equipped with colorful edible ink cartridges (PGI225/CLI226) to print messages on supreme icing sheets, each with 12 pre-cut circles (2.5 inch diameter) in one A4 page. The icing sheets, made from starch and sugar, have a sweet taste and a creamy aroma. All components are FDA compliant. Printed circle sheets were manually pasted onto tea biscuits of similar size using jam

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[13] http://www.ink4cakes.com

(Figure 7.2). Each message was prepared and sealed in a plastic bag and ready for collection within a half day of request receipt. Each message cost about 0.45 USD, which is averaged over the cost of the printer, ink, icing sheets, cookies, and plastic bags. With managerial approval, I opened the message pick-up counter in the employees' canteen during lunch (12-1pm) and dinner (5:30-6:30pm), so as not to interfere with regular working hours. Twice daily, I sent a reminder email to the recipients informing them the next available collection time and location. Printed food messages were kept up to 10 days for collection before being disregarded.

Figure 7.2: Online interface and samples of messages printed on icing sheets and pasted onto cookies.

7.3.2   *Participants*

Since there is no prior knowledge of the potential user group, I applied the self-selected method and snowball sampling this new type of interaction [100], through an email advertisement sent to 20 people randomly selected from the company employee list.

A total of 768 individuals (520 females, 248 males) took part in the study. Among them, 208 participants both sent and received messages using this service, 135 only sent messages, while the other 425 were recipients only. Participants' ages were between 20 and 60 years; 67.3% were aged 20-29, 27.7% were 30-39, and the remaining 5% were 40 or older. Participants held a variety of positions in the company including engineer, programmer, secretary, human resources (HR), sales, and marketing. Use of this service was voluntary with no incentive other than the food messages collected by recipients.

Upon completion of the field study, I contacted 20 participants (5 males, 15 females, ages 21 to 35 years M=26.5, SD=4.5) from the 728 field study participants for follow-up interviews. All had either sent or received at least one food message using our service. Each interview lasted 40-60 minutes. Among them, 13 participants had both sent and received, 5 have only sent, and 2 only received food messages. They came from different divisions of the company, including 6 secretaries, 6 software engineers, 4 hardware engineers, 2 management staff, 1 financial officer, 1 HR officer, and 1 translator. Each successful sending or receipt of a message was counted as one use. Usage frequency of follow-up interviewees is listed in Table 7.1. Each participant received 50 Chinese Yuan (~8.2USD) in cash for participating in the interview.

No. of Usage (Sending or receiving)	1	2~5	6~10	11~20	>20
No. of Interviewees	7	4	4	3	2

Table 7.1: Distribution of interviewees' usage frequency.

7.3.3 Data Collection

Three types of data were collected during the field study: the sender survey, the recipient survey, and follow-up interviews recordings. Both surveys were carefully designed to only contain demographic information and a few 5-point Likert-scale questions. This was to avoid inconveniencing the users to an extent that may stop them from using the service. Senders were asked to fill out the survey online after they submitted each food message request. On average, senders spent 6 min. on the two steps. Recipients filled out a paper survey at the time of collection. Demographic information was only collected from first-time senders or recipients. Each sender would need to specify the relationship with the receiver for each submitted message. There were no complaints about the process. All survey responses were anonymous and kept confidential for research purpose only.

In the follow-up interviews, participants began by describing their first use of food messaging. They then detailed other messages they sent or received, regarding their motivation, reaction, feelings, and how these experiences compared with other messaging methods (e.g., SMS, IM) when applicable.

Specifically, they were guided through these core questions: how did they know about this service, what motivated them to participate, what did they feel when sending or receiving food messages, what motivated them to use or not use the service repeatedly, why did they choose a food message over another form of communication, and was there any difference when using food to deliver a message? Participants also described some scenarios in which they might use this service in the future.

7.4 Data Analysis

I collected 904 messages, 899 copies of sender surveys and 727 copies of receiver surveys. Only five senders skipped the online survey. Some receivers did not collect their messages, as they missed the notifications emails or were out of town. I kept about 900 minutes of audio recordings of the 20 follow-up interviews. All interview data were manually transcribed, translated to English, and coded with the key dimensions I attempted to explore in the study.

Logged online data was used to assess the overall usage trend. Message contents were coded to get a sense of how food impacted the messaging pattern. The surveys captured an overview of participant's subjective senses for this type of messaging, including the sensory, relational, and emotional aspects. Finally, deeper qualitative feedback was gathered from interviews,

which confirms the results obtained from Study 1, and provides more insights into the reasons for observed social phenomena.

7.4.1 Codebook Creation

One of my goals was to understand what content was likely to be sent with a food message. The exploratory interviews indicated that people tend to use food messaging for the purposes of greeting, expressing good wishes, and love. I was interested in finding out if the field study supported this.

Category	Subcategory
Expressive-Positive	Greeting, gratefulness, wish/blessing, encouragement, congratulation, respect/praise, trust/belief, miss, like/love
Expressive-Neutral	Sympathy/comforting, expectation/intention, teasing
Expressive-Negative	Apology, complaint, dislike/hate, worry, confusion/doubt, farewell
Instrumental	Question/answer/response, suggestion/reminder, gifting, request, coordination, information sharing, personal update, miscellaneous

Table 7.2. Codebook: Structural categorization of message based on its communicative function.

The coding scheme lists different types of content possibly carried in a food message. It was developed based on existing work on content analysis of social messaging [2,39,68,89,95,110]. Three researchers reviewed the collected messages, carefully adjusted the categories to better present the collected data, and refined the coding scheme iteratively. More specifically, we first adopted Ma et al.'s categorization of Chinese SMS communication

into Expressive and Instrumental categories as well as its further elaboration of the Instrumental category [110]. We then split the Expressive category into positive, neutral, and negative, and elaborated on each category following Acar and Kimula's method [2]. Ultimately, the codebook divided food messages into four categories: Expressive-Positive, Expressive-Neutral, Expressive-Negative, and Instrumental (Table 7.2). Detailed coding examples are illustrated in Table 7.3.

Category	Subcategory	Example
Expressive-Positive	Greeting	How are you these days?
	Gratefulness	Thank you for your help.
	Wishes/Blessing	Wish you happy every day!
	Encouragement	You must do your best!
	Congratulation	Congratulate on your new life!
	Respect/praise	You are my good leader, good friend.
	Trust/belief	Trust yourself!
	Miss	I miss you…
	Like/love	I love you.
Expressive-Neutral	Sympathy/comforting	Don't be down, it will be over soon.
	Expectation/intention	Looking forward to the next meal.
	Teasing	You lazy dog!
Expressive-Negative	Apology	Sorry that I did not do well this time.
	Complaint	You are not caring me enough.
	Dislike/hate	I don't like the rain these days.
	Worry	I'm afraid that I did something wrong.
	Confusion/doubt	My boss is hard to get along with.
	Farewell	Take care; see you in the near future.
Instrumental	Question/answer /response	Any plan for the coming Sunday?
	Suggestion/reminder	Remember to bring me some candy.
	Gifting	Here is a small gift for you.
	Request	Please let me know if you like it.
	Coordination	How about go out next month?
	Information sharing	It has been raining a lot these days.
	Personal update	I am very busy these days.
	Miscellaneous	Hello world

Table 7.3: Detailed coding scheme.

7.4.2 Coding Process

I recruited three coders who were not involved in the development of the codebook. All were native Chinese speakers proficient in English, majoring in education or with a background in linguistics and communication. To label a message, coders first identified its main category and then narrowed down to a specific subcategory. Each coder could only assign one subcategory to each message. I asked the coders to familiarize the coding scheme with a set of 30 randomly sampled messages. This process ensured that coders understood the codebook and the entire coding process thoroughly and that they had reached substantial agreement on coding sample messages. They then proceeded to manually label the whole dataset. I had a fourth coder review controversial items to resolve disagreements. I combined all three coders' results and successfully generated the final labels for 829 of the 904 entries. Coders did not come to an agreement on the rest 75 messages. I computed the agreement on all the messages including the 30 training items at the subcategory level. The Kappa coefficients of every two coders were all greater than 0.63 (substantial agreement) [100]. I did not include the undecided 75 messages in the final analysis, because I decided they might be semantically ambiguous, making it difficult to interpret senders' intentions.

7.5 Results and Findings

As food printer-mediated social messaging is an envisioned form of future interpersonal communication, I am interested in how likely people are to employ it in real life. Both qualitative and quantitative analysis of data suggested that food messaging has its distinctive content and context of use, and it has the potential to gain wide acceptance in the real world.

7.5.1 Acceptance and Interest

In total, 904 messages were sent using this service during the four-week study. The average numbers of messages sent per day for each week are: 60.6, 20.4, 38, and 61.8 respectively. I speculate the one-day public holiday in week 2 contributed to the drop. But usage increased steadily afterwards.

Through the field study, I learned that 1) there is a significant interest in this method of social messaging; 2) users' interests have converted into actual usage of the service and 3) users found the service offered something unique and valuable as compared to other means of social communication.

Evidence for the first point can be observed from the participant recruitment process. Unlike many other field studies, participants in my study were recruited mainly through viral marketing and friend recommendations. Among the 20 recipients of my first advertisement email, 12 tried food messaging. The

information quickly spread via word of mouth. By the end of the first week, I got 101 new users who sent messages using this service. Another 242 people joined in as new senders in the next three weeks. Even after study completion, I received about 60 additional messaging requests and many phone calls asking if participants could continue to use the service. Although some people stopped using the service after the first week, probably due to the novelty effect, more people joined in and continued to use the service in later weeks, suggesting that food messaging had acquired a group of loyal users with growing interest in the community.

Furthermore, 43% of the senders actually composed more than one message (Figure 7.3), contributing 61.8% of all collected messages. I explored the reasons for the discontinuation after first use of food messaging in follow-up interviews. They revealed two reasons why the retention rate was not very high. One was the disruption of communication flow. Recipient's doubt and ignorance of notification emails led to the message not being collected. If the sender did not get confirmation from the recipient, he or she may stop trying the service. *"I thought it was a trick, so I ignored it, I felt regret when I saw my colleague pick up the food message"* (P4). *"I sent a food message to a friend, but she found the email in the spam box, which was already quite late*

to collect. If I know the service is working, I would definitely try to send more”

(P15). The other reason was the closure of my study: *“I went to the website to*

try more, but realized that the study has closed, what a pity” (P7). That is to

say, I could anticipate more returned users if I could ensure the receipt of the

message and if I had offered the service for a longer period of time.
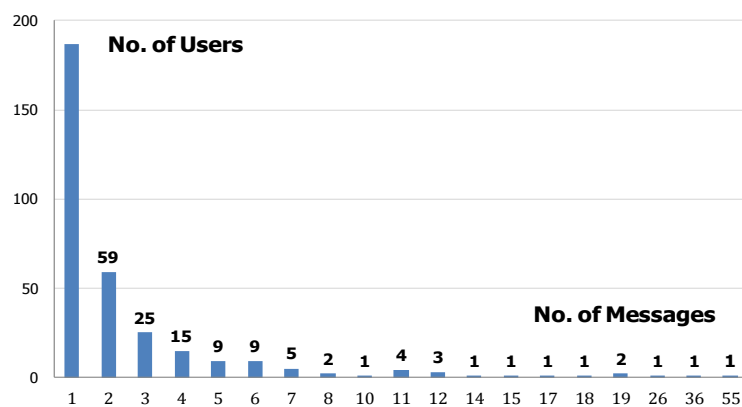
Figure 7.3: Distribution of No. of messages vs. No. of users.

7.5.2 *Overall Rating in Surveys*

The surveys were drafted based on the exploratory interviews in Study 1

(Chapter 6), and aimed to examine the sensory, relational, and emotional

aspects of food messages. A summary of survey results is shown in Figure 7.4

and Figure 7.5.

Overall, both senders and receivers acknowledged the advantages of food

messages in terms of intimacy enhancement, impressiveness, specialty,

playfulness and emotional impact, which verified my findings from the

exploratory interviews. Particularly, playfulness (67.4%) and specialty (64%) got more ratings of "strongly agree" than the others.
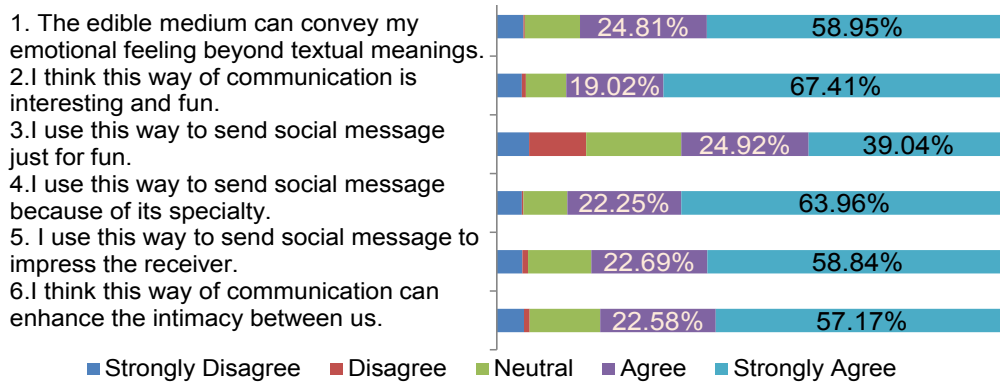
Figure 7.4: Overview of sender survey.
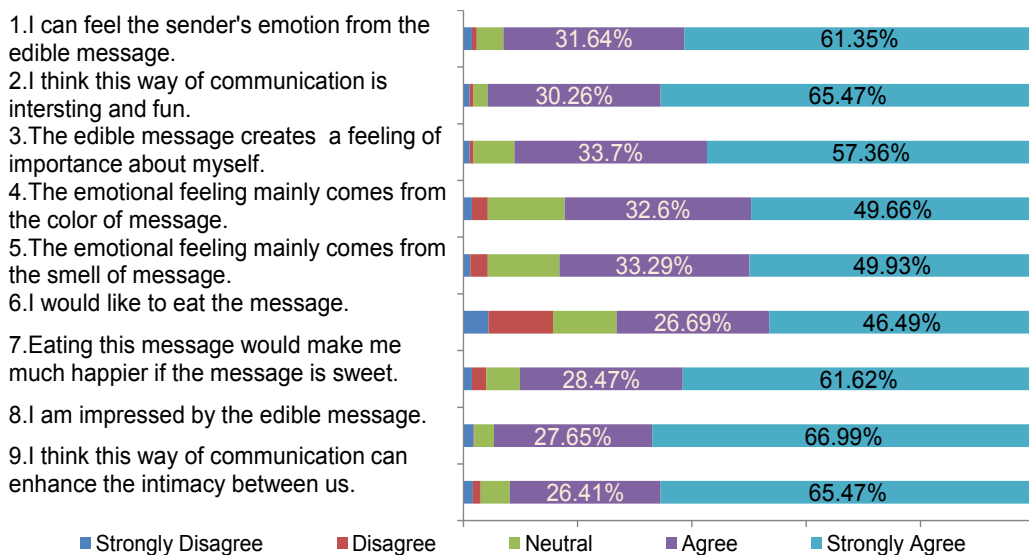
Figure 7.5: Overview of receiver survey.

Although they classified the experience as playful, 64% of senders disagreed with the statement that they "*used this kind of message just for fun*" (Item 3 in Figure 7.4). This suggests that many users found other utilitarian values of food messaging, though they may have initially been attracted by its hedonic thrill. On average, return users rated the survey questions higher than did new

181

users except Item 3 ($p<0.05$ for all the six items). They also reported a higher

level of satisfaction throughout their later usages than they did when using the

service for the first time. I believe return users' interests did not decrease when

the novelty wore off.

On the other hand, female senders rated slightly higher than males except the

Item 3 (Figure 7.6, $p>0.05$ for all items), probably because this messaging

style is easier for the female to accept and try.
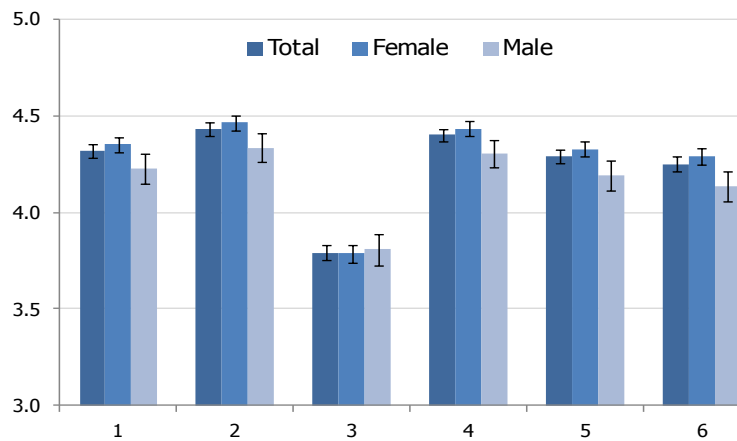
Figure 7.6: Gender vs. Sender Ratings for each statement.
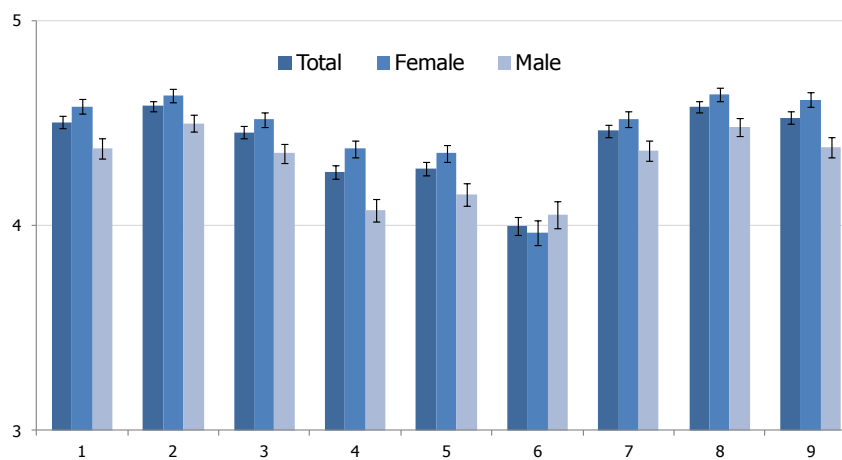
Figure 7.7: Gender vs. Receiver ratings for each statement.

However, there are significant differences between male and female receivers except for the statement "I want to eat the message" ($p_{(S6)}$<0.05). For all the other statements, female receivers rated higher (Figure 7.7). Most female receivers expressed they were not willing to eat it, but keeping it aside. This again verified that edible message is not only more accessible for female, but would be more appreciated by them. The biggest difference comes from the Item 9 - "I think this way of communication can enhance the intimacy between us". Females perceived much stronger sense of intimacy from this edible message than males.

7.5.3 Dimensions of Usage

Having illustrated that the practice was widely accepted, I proceeded to examine detailed usage patterns. In the study, I did not provide any instruction on to whom a food message could be sent nor what could be written. This enabled me to explore the dimensions of how people may use it in daily life. I also compared the patterns between male and female users, since perceptions about new technology are subject to gender analysis [90].

7.5.3.1 Gender Bias

More detailed analysis shows the user population had a slight gender bias towards females. Although the majority of the employees of this company

were male (~80%), 74% of senders were female. Also, more female users continued to use the service after trying it once (68.7% of females vs. 41.6% of males). One possible reason is that females are generally more sentimental and more willing to express their feelings [96]. Another possible reason is the attitude and behavior difference between genders towards gift giving, as "women are more likely to possess a positive orientation towards gift giving, and they are largely responsible for the practice of giving" [169]. Some male interviewees told me that they appreciated food messaging and wanted to use food messages, but felt shy or unnatural as a guy using them.

7.5.3.2 Tendency toward Close Relationships

I observed heavier usage of food messaging between dyads with relatively close relationship (Figure 7.8): colleagues, good friends, husbands/wives, parents/children, and boy/girlfriends. Although the total number of messages sent to people in close relationships didn't rank first, the results showed that people were more likely to send their first food message to their closest ties, such as family and boyfriend/girlfriend, and then expanded to colleagues and good friends as returned users (Figure 7.9). Because food messages are deemed distinctive and precious, they are prioritized for love ones.
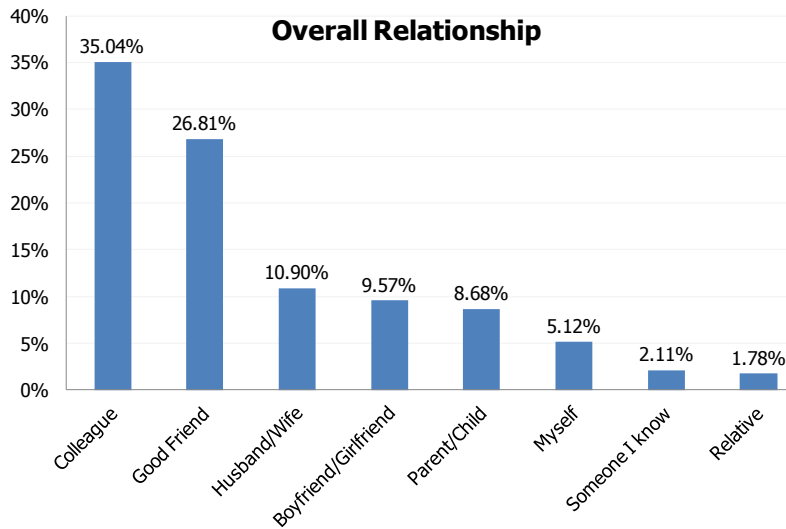
Figure 7.8: Overall distribution of relationships.
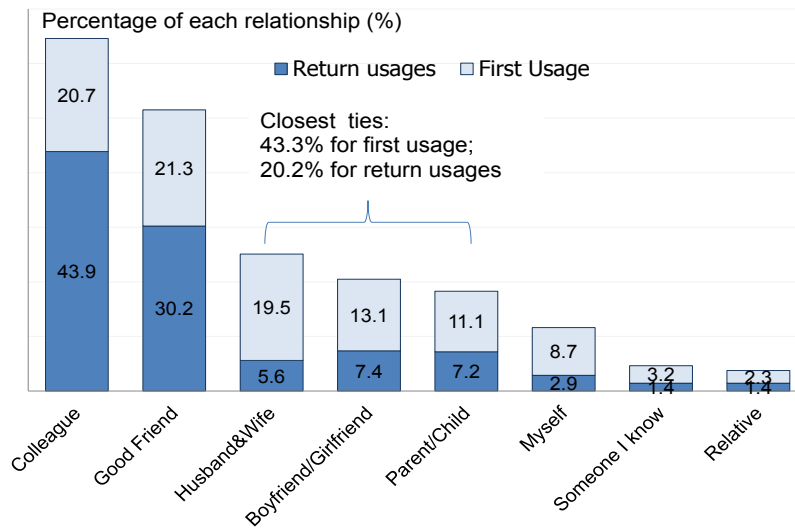
Figure 7.9: Cross Analysis: User type vs. Relationship.
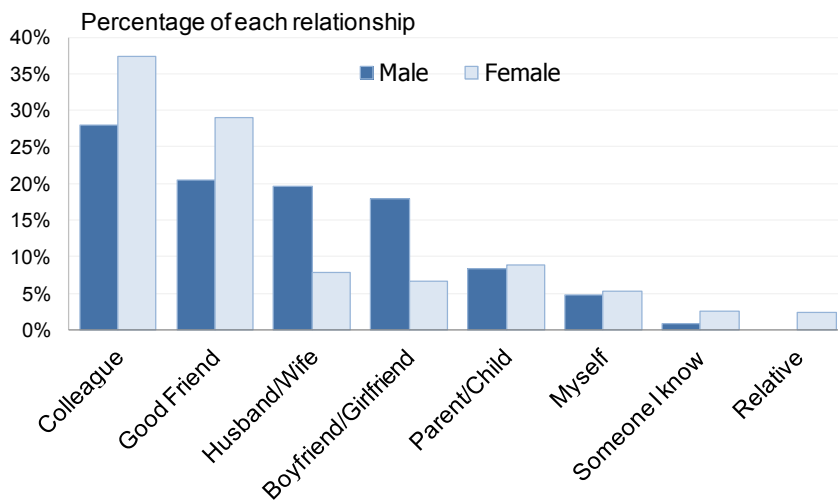
Figure 7.10: Cross Analysis: Gender vs. Relationship.

Although both showed a greater tendency to close ties, a larger portion of male users sent to significant others (a total of 38% of males, and 15% of females), like husband/wife or boy/girlfriend; while females were more keen to message colleagues and friends (Figure 7.10, *n.s.*). I speculate males are relatively more prudential than females when using food messaging. This again reflects the literature on gift giving, which indicated "women give to a wider network of receivers, while men are more likely to give substantial gifts confined to spouses and quasi-spouses" [169].

7.5.3.3 Types of Messages

Figure 7.11 shows the overall distribution of the communicative functions of food messages based on our manual coding. Generally, senders used food messages primarily for positive expressions. Seventy-eight percent of messages fell into the Expressive-Positive category, followed by the Instrumental category (18.1%). People rarely used food messaging for negative or neutral expression. Only a few messages were complaints ("*you are not easy to get along with*"), or confusion/doubt ("*maybe it is a trick*"). These findings are quite different from previous studies on mature communication methods. SMS was reported to be mainly instrumental for planning of events/get-togethers, coordinating meals times, organizing rides

[15] and exchanging information [110]. Common types of digital messages, such as coordination and personal updates, did not appear in the data.

More specifically, although expressive messages dominated the communication initiated by both genders, males were slightly more inclined to send informative messages. Of senders, 80.8% of females and 70.4% of males composed expressive messages with positive emotions, while 15.4% of females and 25.5% of males sent instrumental messages. These results are compatible with the initial interview, in which participants described their preferred usages of food messages to deliver positive messages, especially greetings, congratulations, and good wishes.
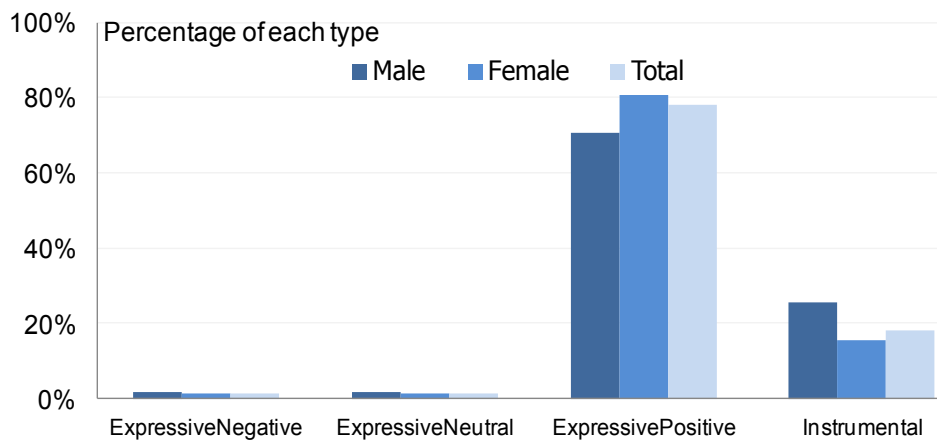
Figure 7.11: Distribution of message category between genders.

As for the subcategories, 55% of the messages were wishes/blessings (Figure 7.12). I further labeled the specific topics of each message of this type. Results reveal that wishes covered a range of topics: happy and smooth life, health,

career, romantic relationship and marriage, beauty, birthday, having a baby, and wealth, etc. Many messages have several topics, e.g., "*Be happy and find your Mr. Right soon,*" and "*Wish you a bright future and happy forever.*" Different topics targeted different recipients. Happiness was the most frequent mentioned, especially among colleagues and good friends. People also sent career wishes to colleagues, marriage/childbirth wishes to good friends, and health wishes to family members. I can clearly see such differences when a same sender delivered messages to several receivers. One probable explanation is that marriage and childbirth are more personal and thus may not be as appropriate to bring up with those not as close. Food messages provide an edible substitute for traditional wishes.
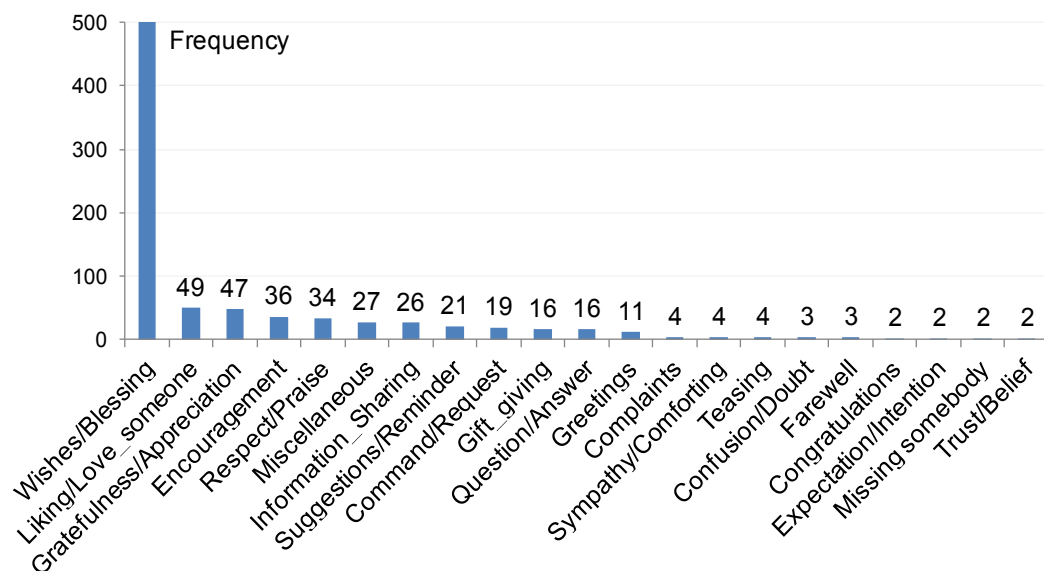
Figure 7.12: Distribution of messages among subcategories.

As shown in Figure 7.12, other common subcategories included like/love someone, gratefulness/appreciation, encouragement, and respect/praise, all of which are positive expressions. The more commonly used instrumental purposes included information sharing, suggestion/reminder, and command/request. Participants did not send any message for negative expressions of dislike/hate or worry in the study, which agreed with my exploratory interviews.

On the other hand, I am aware of the potential effect from the use of cookie in this study. Cookie as a type of confectionery food may have led to the association of message content to generally positive expressions. I investigated people's thoughts on food type in the interviews, and the results seem to be the other way round. That is, people normally consider food to deliver positive emotional messages rather than the other types, thus they would prefer to choose sweet food, especially candy, cake and chocolate, which they think are compatible with the purpose. And cookie may not have so strong emotional sense as those foods.

I also noticed messages that are adaptive to the edible property, with content related to health, food, and eating. For example, "*Keep healthy*", "*Eat my wishes*", "*Swallow the luck*", etc. This reflects what suggested in Chapter 6,

and makes food potentially a good conveyor of messages in special situations, such as to encourage healthy eating with reminders printed on food, and to create new experiences of receiving messages in body.

7.6 Discussion

The results from the field study and the subsequent interviews have drawn a rich picture of how people communicated with others through food messaging. In this section, I will discuss the fundamental and distinctive properties of food as a messaging medium and suggest its appropriate niche among mainstream communication media.

7.6.1 Impact of Physical Properties

A food message's physical presence makes it a unique communication channel. First, food is tangible and also edible. It can stimulate the sensations of smell and taste besides sight and touch, enhancing communication richness [67]. In addition, physicality plays an important role in interpersonal communication [24]. Food not only provides a tangible platform to display text messages that traditionally appear in the virtual space, but also serves as a physical embodiment of affection and care [137]. Unlike a note or Facebook message, recipients could better sense such emotional expression via consumption of the edible messages, "*It's physical, I can feel it, when I eat it, feels like the good*

words go into my body" (P3). This triggers a multimodal sensational and emotional response, and the taste of food nicely complements the meaning of the message [12]. Different types of food can be combined with different types of messages to create enriched and unique experiences: "*I can taste and digest the words slowly when eating the food message, it's not like just see it, and then forget about it. Food message is more impressive for me*" (P11).

Second, the production of a food message takes effort and involves physical materials, and thus people were more attentive and careful when crafting food messages. Sixteen out of the 20 interviewees indicated that they would go over the content cautiously, "*I would carefully write nice sentences, revise them a few times, and check for typos or grammar errors. It is like writing an essay, and have all words to be meaningful*" (P16). *"For SMS, I rarely pay much attention. I use slang and usually don't bother with spelling"* (P 20).

Consequently, recipients were often impressed and touched by such efforts. "*It's not just a sentence; I can feel his efforts and care for me*" (P9). Digesting the messages also reinforce recipients to memorize the content by heart since they cannot be reprocessed once consumed. One interviewee noted, "*I usually forgot the content I sent or received from SMS and online chatting, but I can remember clearly the words on food, and also who sent it to me*" (P18). The

data showed most receivers, especially females, opted not to eat food messages immediately. Some even expressed the interest of preserving the message. They first took photos, displayed messages on their desks, or kept them in the refrigerator. As suggested, if senders devoted greater efforts into composing a text or multimedia message, recipients were more likely to save and cherish it [76,90,105,161].

Third, food as a physical medium also has limitations, such as low immediacy and synchronicity, difficulty in preservation - especially their smell and taste in spite of the lasting psychological impact on receivers, relatively higher monetary cost of materials and delivery, and the concern of food safety.

In sum, food's physicality and multimodality afford extra meanings (such as perceived efforts and care) in communication implicitly. But they also suggest that food message would not be practical for chatting. It is difficult for food messaging to keep the flow of an instant conversation as text messaging does because it takes more time to compose and deliver. Similarly, it is not for urgent situations or other contexts that expect quick responses. Also, being generally sentimental and subjective, food messages rarely carry formal and serious conversations.

7.6.2 Impact of Social and Emotional Properties

Many people considered food messaging as "*informal gift-giving*", rather than a simple exchange of factual information. As a common practice in everyday life, gift-giving ties people together [78]. This suggests that food messaging, if used widely and wisely, can enhance social connection in many ways.

First, people tended to use food messaging for special people or on special occasions (birthday, wedding, etc.). Closeness in relationship affected the priority and characteristics of social communication [78]. "*I would be willing to allocate more efforts to people I really care, and I think food message is worth my time*" (P2). Even if the same user delivered food messages to different people, he or she likely used the service differently. "*I would send multiple messages to my girlfriend regularly, but only once in a while to other friends*" (P5). In other words, receiving a food message makes people feel that they are valued more in the sender's social circle [78].

Second, most food messages were used to "*bring happiness to the receiver.*" Comfort food often positively evokes sentimental feelings [108]. "*Food naturally makes people happy; it would contradict with the meaning of food if you used unsavory food to express negative feelings*" (P15). The emotional impact can also come from its "*recollection of happy moments.*" "*This*

reminds me of the festival traditions when we greet each other with food, and everyone feels delightful" (P7). Therefore, people are more likely to use the exchange of food messages to signify thanks, caring, love, and trust, with the intention of promoting well-being and the feeling of warmth for recipients [78]. *"It contracts with the nature of food if you use food message to criticize people"* (P1).

In other words, food has a stronger and longer emotional impact, which makes it generally unsuitable for delivering negative information. *"We don't want to keep the unhappy feelings for long, so we won't use food for unpleasant messages"* (P3). Notably, people agreed that communicating apology or rejection via food is rather sincere and acceptable. Food may alleviate the pain brought along with the negative experiences associated with the words.

Third, food messages may be used to repair and strengthen distant social bonds. For example, some participants recovered friendship via the service. *"I had some unpleasant experience with a friend, and we haven't talked to each other since then. Neither of us wants to say sorry. Knowing this service, I sent her a food message with normal greeting – Happy Every Day. We got over the unhappiness and are good friends again"* (P10). Food messaging was even more powerful in maintaining social relationships. As mentioned by one user,

"I actually don't text my friends any more recently. We are just too busy and lazy, and it seems that we have nothing to say. But this kind of message really shows your care to others. It feels good to read the words from their hearts, which people might be too shy to speak out directly" (P14).
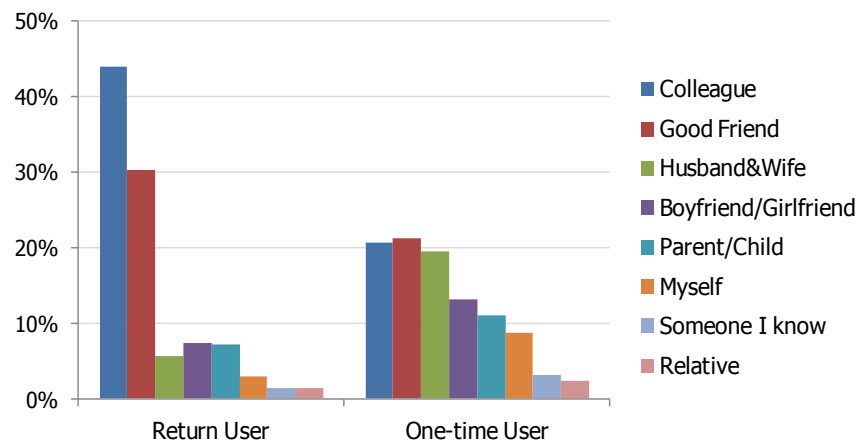
Figure 7.13: User type vs. Distribution of relationship.

Fourth, although people are more inclined to keep it personal, food messages can potentially encourage productive group dynamics and generate positive social climate. As shown in Figure 7.13, reusing of food messaging mainly spread to colleagues and friends, indicating the effectiveness of food messaging to enhance group dynamics and bring people closer. As one user noted, "*All the people in my office are using this, and we are telling our friends about it. We are interacting more often now across different divisions in the company*" (P13). In the data, many users wrote back via food messaging. Interviewees also mentioned using conventional channels (phone calls, online

chat) to contact senders, similar to gift giving communication. This suggests

food messaging can facilitate social dynamics and rebuild social connections.

If this service becomes more accessible to people in the long run, they can use

it to increase group cohesion in organizations or other social groups (e.g.,

family, friends, and communities).

Fifth, in the study, I also noticed a phenomenon that rarely occurs in

traditional messaging. Although I introduced food messaging as a social

channel, 46 messages (5%) were addressed to the senders themselves.

Different from self-reminders on sticky notes, these messages served mostly

as encouragement, appreciation, or expectation, all of which are in Expressive-

Positive category. Examples include "*I am the best*," and "*I will be*

successful." This actually follows the common practice of using food as an

incentive or reward, as "food is a source of both bodily and spiritual

empowerment" [37].

7.6.3 *Motivation*

In the follow-up interviews, I found the most common initial motivation to try

the service was curiosity, but the strong appreciation of recipients motivated

senders to use food messaging again and also turned recipients into senders.

"*My girlfriend like it so much, and she asked me to send more to her*" (P10), "*I*

tried it first to see what it is, soon my friend asked me for the link, since she and her colleagues all want to use this service" (P14). "*I feel very happy to receive it, and I would like to receive more*" (P1). Specifically, 208 out of the 633 receivers turned into senders, which broadened the participant circle. Exploratory interviews and field study revealed that emotional impact is a significant factor that makes food messaging distinctive [108]. Increased intimacy was frequently mentioned, "*I feel so warm when see the message on food, it brings us closer*" (P1). "*I never feel so close when reading my friend's words*" (P3).

People have a strong desire to send and receive emotional expressions. Therefore, the intention to impress receivers and make them feel important and special has sustained and broadened the usage of food messaging. One user even sent as many as 55 messages during the study.

In summary, food as a message medium seems to facilitate emotional and impressive communication beyond information exchange. Because of this, the participants leveraged food messaging to express wishes, affection, and appreciation to those they care for in a way that combines traditional gift giving and messaging.

7.7 Implications for Future Design

I have gained a better understanding of how food may function as a social messaging medium in practice. The findings uncovered factors that motivate food messaging besides playfulness and novelty, and provide implications for future design and research on communication via food.

I consider food not as a replacement for current messaging, but more as a complementary channel in specific contexts that can benefit from its unique advantages in emotional expression. R. Harper considered sending and receiving mobile text messages a form of gift-giving [78]. The physical presence of food message provides an even stronger sense of gifting than a message alone. However, as it is meant for daily messaging that occurs at high frequency and cannot be kept as mementos since it decays, food messaging is less formal than traditional gifts. It can be used together with other media or traditional gifts to create a new communication experience. All interviewees expressed their desire to use food messaging in the future, especially with more convenient composition and delivery services. One possible design is to extend existing messaging applications to allow users to produce an edible message with a specified food printer.

Food acts both literally and symbolically as a gift [67]: individuals give food (e.g. chocolate) as gifts at festivals like Valentine's Day in Western countries and Spring Festival in China. The process of preparing food becomes embedded in the gift that can be consumed by the recipient. Chinese and many other cultures share similar value regarding the symbolism corresponding with gifting, "it is always not the gift, but the thought that counts." Edible words make messages more explicit than the traditional practice of food giving, but the ritual's intent is maintained. In this case, the recipient could literally and symbolically consume an offering of wishes and care. Interviewees indicated the profound feeling beyond words, "*It's more touching than digital messages*" (P12), "*I care more about the text content than food itself; but food definitely makes the words more impressive*" (P5).

In Eastern Asia's culture (such as Chinese or Japanese), people tend to express feelings in subtle ways, like gifting. As copious emotional messages were sent in the study, I believe Chinese people may benefit from this messaging method as a channel to express emotions more explicitly. Future design could take advantage of food to facilitate and enhance people's expression of love and care in daily life. For example, if the service is embedded in cooking

appliances, users could express different messages to each family member on their dishes, customizing the message content and flavor with different foods.

Moreover, as McLuhan says, "the medium is the message" [117]. For food messages, their physicality, emotional and cultural associations, and evoked sensations can enrich receivers' interpretations. Every food could carry different meanings based on its color, texture, smell and taste. Chocolate means love and intimacy, while fruit may be considered as health and fresh. When preparing food as a gift, the person often takes into account the likes and dislikes of the intended recipients and the context of gifting. For example, the types of food may vary with the subject or occasion, and reflect cultural tradition as well. *"I like to send my wishes with rice dumplings on Dragon Boat Day, moon cake on Middle Autumn Day, and chocolate on Valentine's Day"* (P8). Therefore, it is necessary and of great value to allow selective food ingredients in the food messaging service in the future.

Participants also commented on how they want to use food messaging in the future. The most mentioned suggestion was to use handwriting as the input method rather than typing, which enhances the sense of crafting and personalizing a message: *"If the message is printed in the style of my handwriting, it feels more like being made by myself."* (P17) On the other hand,

although the service did not support printing messages with different tastes in the study, my participants suggested that using different food types and taste can further enhance the unique advantages of food messaging, as there is often a strong correlation between food type, taste, and the emotional expressions the sender may want to convey to their receivers. For example, besides using typical sweet food, they also desire to use sour food to tease a close friend. I hope this could be explored in the future.

Moreover, although the service in this study did not support 3D printing or full automation of messages delivery, the insights were informative. Our participants did not seem to be concerned about the operator's access of message content, as the content typically did not contain sensitive information. Privacy concerns can be mitigated when food messaging service becomes further expedited and automated by food printers marketed for use at work and home with higher efficiency. Moreover, a 3D food printer would bring an additional expressive dimension in designing the shape and look of food messages, which can be investigated in future research.

7.8 Summary

In a world that more and more people are computer literate, text-based social messaging in various forms, e.g. email, SMS, IM, and social media posts, has

become a mainstream method for social communication [73]. However, digital text messaging typically lacks expressiveness and human embodiment [4], leaving room for new media that can transmit emotional expressions.

In this chapter, I presented empirical investigations on the applicability of food as a messaging medium. More specifically, I demonstrated people's acceptance and perception of food messaging and identified its scenarios of use. Generally, people used food messages to express positive feelings to relatively close relationships, motivated by its modalities and emotional impact beyond words.

In terms of viability, I found that food messaging can raise and maintain a steady customer based over time. Though used mainly as a means to express positive feelings to people with close relationships, messaging through food covers a wide range of topics, and fosters sender-receiver relations with varying closeness. It was shown to favorably affect recipients by evoking positive emotional reaction beyond that of what similar messages sent over existing forms would have elicited.

These results suggest that food messaging has the potential of becoming an important complementary channel of social messaging. It produces and

delivers messages that can be literally consumed and more deeply felt by recipients than traditional forms of messaging. As a hybrid between explicit communication via words and implicit expression through sensations and emotions, food messaging affords a unique niche in social messaging that could greatly facilitate group dynamics and social cohesion.

Studies of human communication with interactive technology tend to emphasize on effectiveness improvement, which may overlook users' emotional experience. Therefore, I particularly focused on how food promotes "consummatory communication" (versus "instrumental communication"), which typically involves affective satisfaction, social connectedness, sharing of experience, emotions, etc [61]. In other words, I consider food messaging to be more user-oriented, rather than task-oriented.

The empirical results improved the understanding of food in social messaging, which can lay the foundation for specific controlled experiment in the future, to further compare the usage of different media types, and may also inspire new types of communication patterns that people welcome. This field study has shown promise for strengthening social ties and providing an outlet for both digital and physical messaging that is functional and affective.

Chapter 8

Discussion

This chapter begins by discussing the enriched communication experience provided by digital technologies with food, and then moves on to the potential paths that might extend the expressiveness and range of applications for interaction via food. Following that are implications for further exploration in related domains and alternate design spaces opened by this research. This chapter also considers possible avenues for applied use of the developed two prototypes from the studies.

8.1 Enriched Communication by Food

This dissertation has worked to enrich both traditional food-mediated communication (remote dinner) and the current digital communication (digital messaging) by emphasizing the communicative properties of food, making steps towards using food and technology to enhance communication experience beyond digital connection.

Through the prototyping, empirical studies, and analysis, I identified the distinctive properties of food as a social medium. First, food is tangible and

also edible, which can stimulate the sensation of smell and taste in addition to sight and touch, enhancing communication richness. Second, food is physical, thus takes more efforts to make; and comfort food often positively evokes sentimental feelings, with lasting psychological impact on receivers. Food also comes with a variety of social practices that could be supported and enhanced by media technologies. These properties may lead to both physical and emotional communicative impacts on food-mediated communication.

This research proposed two approaches of combining food and technology to mediate communication and social interaction: applying technology to existing food activities, and applying food to existing technological communication practice. It performed two case studies: CoDine enriched food-based interaction during remote dinner, and food messaging enabled a rich alternative communication method for text messaging.

Specifically, CoDine applied digital technology onto food and dinner ware to provide additional food-based interactions. Previous systems for remote dining primarily used video recording, projection, and virtual avatars to allow remote parties to hear and see the presence of each other. CoDine, additionally, also allows the two parties to interact through a series of dining activities: gesture-based screen interaction, mutual food serving, animated emoticons on

tablecloth, and teleporting edible messages with smell and taste. The technological intervention focuses on reconstructing the missing multi-sensory property of food in a remote dining experience. CoDine added important elements, such as food activities and multi-sensory experience, to remote dining, preserving the ritual activity like food serving and also creating new channels like tablecloth expression and food teleportation, beyond video conferencing. It is through these physical interactions that people engage themselves into the shared dining experience with feeling of "being together".

On the other hand, food messaging leverages food's sensory and emotional affordances to augment text messaging. Existing social messages mainly take the form of text on paper or digital media, which affords limited social cues and perceived social values. With its unique properties of being sensory, symbolic and emotional, food as a message carrier could enrich the existing social messaging practice, enabling the delivery of verbal messages together with non-verbal expressive meanings. Participants considered it combined elements of traditional food gifting and text messaging, which made the communication experience multi-sensory and impressive. As a hybrid between explicit communication via words and implicit expression through sensations and emotions, food messaging affords a unique niche in messaging

communication that could greatly facilitate people's everyday communication and interaction with each other.

In both cases, social communication and interaction were enriched with additional modalities to achieve physical and multi-sensory experience. Although a number of research works have explored ways to mediate food socialization, they did not target at the specific context around food, nor did they investigate the core values of food in mediating communication. In other words, they did not treat food as the center of communication. Through the presented landscape of food media and two cases, I demonstrated how food brings people together in a new way, an expressive and evocative way, creating enhanced experience of human bonding.

8.2 Implications for Further Exploration

This dissertation looked into two aspects of combining food and technology. The results and insights provide implications for further research.

Applying Technology to Food-based Interaction

Digital technologies could preserve and add new senses to food-based interactions for enriched social experience beyond digital smartness. Dinner communication is far more than just seeing and hearing each other. It also

involves a range of communication and interaction through non-verbal channels. In this research, I considered dining as a social ritual that holds various communication elements, involving people, food and dinnerware, together with dining etiquettes that provide a basic structure for social engagement. Preserving the roles of food in mealtime communication of meanings and emotions requires thinking beyond digital enhancement of food preparation and eating. Therefore, it is valuable to consider designing for enhanced social presence and co-experience, by incorporating additional channels (modalities, interactive activities) for communication.

Applying Food to Communication Technology

Food combined with technology could preserve and add new senses into the digital-dominated communication as well. By researching into the communicative affordances of food, I revealed the viability and distinctive values of food in social messaging.

First, in response to the critics of digital communication as being cold and lightweight, I provided a potential solution that enabled social communication with enhanced sense of warmth and emotional impact. The properties of food make it intuitive to generate touching and warm feelings on humans. The

results implied that food would be an appropriate substitute for expressional communication. It may impress more perceived values than plain words, but is less formal than traditional gifting. It is fairly possible to be applied to other communication such as storytelling and sharing pictures to foster enriched experience.

Second, the detailed analysis of food from various dimensions and the empirical study results revealed the benefits and risks of communication via food, which can inform when to use and not to use food according to different social contexts, e.g. purposes, relationships, and variations of closeness, and how food should be adopted to afford richer meanings. For example, food messaging would be more preferred in close social ties, for expressions rather than instrumental purposes.

Moreover, food incorporates multiple modalities that can be sensed. The empirical results will help future studies to further investigate how messages should be conveyed in terms of vision, smell, and taste, catered to particular social context and communication purpose. The number of senses stimulated and the intensity of the experience are inextricably linked, so the more senses you can involve, the more intense your messages will be [131].

Overall, this research was based on a broader definition of social medium, i.e. more than a conveyor of information, but rather a pack of the integrated communication experience, reflected by Postman's definition [146]. "The medium is the message" is a prominent phrase stated by Marshall McLuhan [117]. As it expresses the form of a medium embeds itself in the message, producing symbolic and associated meanings. As revealed in this research, a communication medium can influence users' experience not only by the content delivered over it, but also by the characteristics of the medium itself. For food messages, their physicality, emotional and cultural associations, and evoked sensations can enrich receivers' interpretations. Every food could carry different meanings based on its color, texture, smell and taste. Chocolate means love and intimacy, while fruit may be considered as health and fresh. When preparing food as a gift, the person often takes into account the likes and dislikes of the intended recipients and the context of gifting. I hope this research can facilitate further explorations towards appropriating the communicative affordances of food to construct food and media technologies in ways that maintain social cohesion.

8.3 Paths towards Applied Use

Regarding food media, I was also interested to explore the possible paths by which this research might find its way into a world of more widespread use, and the potential issues that need to be considered along the way.

Most participants expressed strong desires to see the designed communication methods come to daily life in the near future, and they would like to use them both in public and domestic space. One applicable setting suggested for CoDine is places that associate with warm and hedonic atmosphere, such as hotel lounges and exquisite restaurants. When people are at the hotel, they are always on travel thus being away from their loved ones, and eating alone would aggregate their feeling of homesick; CoDine can provide them with the opportunity to catch up with their families at home with shared dining experience. Food Messaging, on the other hand, can be embedded into a vending machine and connected with digital SNS to circuit social message in both digital and edible formats with higher flexibility.

Also some participants preferred to have these systems at home for personal usage. Imagine you can have dinner together with remote parents or grandparents once a week，or send and receive "Good Morning" on your breakfast from a close friend. It also provides a good solution for parents who desire to compensate for their absence from kids' special occasions. For

example, busy father may feel very guilty for not being able to celebrate son's birthday. Sending personal words on a cake to son's birthday party would transmit his love in an impressive way. They would consider the system more for personal life and more suitable for private and intimate communication.

On the other hand, participants did raise some concerns regarding the consumer usage. One issue is convenience, regarding setting up and maintenance. Especially for the food printer mechanism, appropriate design is required to support easy installation, ingredient change and cleaning of components. The other issue is food safety; "the minimum touch with food" is a suggested rule from a business investigator. I hope advanced manufacture technologies can help to solve this problem and push these technologies into real life.

Chapter 9

Conclusion

Humans are social beings, we have a fundamental need to communicate, to form, maintain and enhance social relationships [82]. The fast proliferation of email, Internet chat, teleconferencing platforms and other telecommunication systems underline the importance of developing communication methods that are sensitive to the human experience with these systems.

This research builds on and contributes to the growing body of literature on social communication, demonstrating the potentials of food and technology on enriching communication experience, specifically, communication during remote dining and text messaging. Food plays an important role in everyday life, through sustaining life, creating culture, maintaining social ties, or crafting identity. As a visible, shareable, and consumable cultural product, food is fundamental to the creation and maintenance of group identities [113]. Food has become increasingly important within our processes of communication as a means of expression, manifestation of identities, and hallmark of social relationships [40]. Therefore, I believe communication

studies can offer new insights into how food combined with technology as a medium provides much more than nourishment, and how it complements or advances the current communication media.

9.1 Contributions

This research explored the potentials of food and technology to provide different social experience rather than task efficiency. Extending the growing literature in this area, I looked to expand the range of food-mediated communication by examining the in-depth roles of food in supporting positive physical and emotional responses, with a focus on the social and situated nature of food interactions, the internal physicality, sociability and emotional associations. This research has several contributions.

First, this research identified two properties of food that are potential for technological intervention in mediated communication, based on a comprehensive review of literature on food and media theories. On one hand, food-based activities have crucial roles in interpersonal communication; on the other hand, food is multi-sensory; it affords rich social cues such as visual, touch, smell and taste, together with embodied symbolism that could trigger physical and emotional impacts on communication. Although food has been thoroughly discussed in several domains like sociology, culture, and

nutriology, I specifically focused on its communicative affordances integrated with digital technology.

Second, this research explored two approaches that utilized such properties to enrich social communication and interaction: incorporating technology with food-related social activities, and involving food to technological communication. Correspondingly, it investigated two cases that reflected "food media" (defined as food and digital technology as a social medium).

a) CoDine system

This case applied interactive technology to enrich social interactions in remote dining. The original idea of co-dining, defined as "the sense of being together when dining remotely", was introduced and explored. Previous systems for remote dining primarily used video recording, projection, and virtual avatars to allow remote parties to hear and see the presence of each other. CoDine, additionally, also allows the two parties to interact through a series of dining activities: gesture-based screen interaction, mutual food serving, animated emoticons on tablecloth, and teleporting edible messages with smell and taste. It uses interactive techniques applied upon physical dinnerware to reconstruct the missing multisensory experience of food in remote dining. It incorporates

additional modalities like touch, smell and taste, and interactions (food serving, tablecloth expression, and food teleportation) into remote co-dining experience, to achieve physical and multi-sensory experience beyond video chatting. It is through these physical interactions that people engage themselves into the shared dining experience with feeling of "being together".

b) Food Messaging

This case utilized food to enable an alternative messaging method. Existing social messages mainly take the form of text on paper or digital media, which affords limited social cues and perceived social values. With unique properties of being sensory, symbolic and emotional, food as a message carrier could enrich the social messaging practice. Edible messages adopt food's sensory and emotional affordances to deliver rich expressions beyond words. It was shown that food messaging combines elements of traditional food gifting and text messaging, making the communication experience multi-sensory and impressive.

Further, this research plotted out the unique dimensions of using food messaging and fundamental properties of food as a messaging medium, based

on rich empirical data collected from a series of studies including exploratory interviews, surveys, field study.

b1. Demonstrated the *feasibility*, *usage* and *perceptions* of a new way of food-based messaging

The results of exploratory interview with 12 potential users and a field study involving 768 users demonstrated people's strong acceptance and perception of food messaging and identified its scenarios of use.

People generally welcome the idea of food messaging, and users' interests were converted into actual usage of the service. Food was described as "*the most impressive and special, with the highest perceived value*", compared with digital and paper messages. Field study data further revealed that food messaging is preferred in close relationship especially when sending the first food message. The manual coding of 904 messages showed that people are more likely to use the exchange of food messages to signify positive expressions (78%). It was considered as "*informal gift-giving*", rather than a simple exchange of factual information. Receiving a food message makes people feel more valued in the sender's social circle.

Additionally, empirical data uncovered the different behaviors between genders in using food messaging. The user population had a slight bias toward females. 74% of senders were female, and more females continued to use the service after trying it once. Moreover, although both genders showed greater tendency towards close ties, a larger portion of males sent to significant others than females, like husband/wife or boy/girlfriend, while females were more keen to message colleagues and friends. Both of these phenomena are compatible with the gender differences reflected in gift giving practice.

b2. Identified the fundamental and distinctive properties of food as a messaging medium and suggested its appropriate niche among mainstream messaging media

First, food is tangible and also edible. It can stimulate the sensations of smell and taste besides sight and touch, enhancing communication richness. Second, the production of a food message takes effort, and thus people were more attentive and careful when crafting food messages. Consequently, recipients were often impressed and touched by such efforts. Edible words make the messages with food more explicit than the traditional practice of food giving, but the ritual's intent is maintained. The recipient could literally and symbolically consume an offering of wishes and care. I believe people may

benefit from this messaging method to express emotions more explicitly, rather than in subtle ways.

Third, this research suggested implications for future works on combining food with technology to enhance social communication and interaction. Generally, technology can maintain and add new modalities to the traditional food practices by focusing on the communicative properties of food. In remote dining, interactive activities and multimodality of food could achieve co-dining experience and enhanced engagement between remote parties. On the other hand, food as a messaging medium affords a unique niche in messaging communication, especially appropriate for positive expressions and impressing a sense of gift. Moreover, food has both advantages and disadvantages in communication and preferred scenarios of use, which needs to be carefully considered to identify the appropriate context. For both approaches, it is important to carefully consider how to make better use of food's social roles and properties to complement specific communication. Empirical results suggested future explorations to highlight three main aspects: physicality, shared activities, and symbolic associations with food's sensory modalities. Food's physicality and multimodality could generate extra affordances in mediated communication, implicitly and explicitly.

To sum up, this research focused on how technology can be combined with food to promote "consummatory communication" (versus "instrumental communication", typically involves affective satisfaction, social connectedness, sharing of experience, emotions, etc). Exploiting food, the presence of technology could enrich physical and emotional communication experience. This research identified such properties of food, and employed two approaches to utilize them to enrich communication, which were further investigated through prototyping and empirical studies. In a word, I deepened the understanding and technological adoption of food as a social medium in the contexts of remote dinner communication and social messaging.

9.2 Limitations and Future work

This research created two prototypes to investigate two cases of food media, with followed studies to evaluate the system design and user experience. There are limitations, regarding the prototype capabilities and study design.

The two prototypes were motivated by experience-oriented design, thus less emphasis on system performance. Hardware and software refinement would be helpful to enhance their capabilities and robustness, such as moving accuracy of step motors in Hosting Table and Food Teleportation, faster

recognition of hand gestures in the Interaction Screen, which would make the interactions smoother for users.

On the other hand, the studies can be improved in several aspects. For CoDine, paired setting of participants would be helpful to obtain more about the co-dining experience. However, due to unexpected changes in lab administration, the other set of prototype was unavailable. A comparative study with other systems in related works would be another option, but facing the difficulty of replicating the system developed by other researchers.

In addition, I was aware of the potential bias resulting from the user group, since the opinions and behaviors of convenient sampling group may not represent the entire population. On one hand, they were recruited on campus and are relatively young, thus it is easier for them to accept new things compared with older people. On the other hand, most of the participants are away from home. The results would be stronger if comparison was made with people who usually have real co-dining. Another factor that requires further investigation is the effect of food compared with the designed dining activities. A controlled experiment between with and without food is necessary to assess how much of the evaluated experience is due to the food and activity modules respectively.

As for the studies on Food Messaging, although I generated thoughts across different cultures in both Study 1 and Study 2, it would be helpful to investigate these questions within a same cultural group to detail their opinions on these types of media. Study 2 gathered responses from a much wider audience, but involves only Mechanical Turk users, the results may be different with the general public.

Moreover, results from the empirical study and follow-up interviews shed some insights on the adoption and perception of food messaging in real scenarios, but the novelty effect can't be excluded although the study last for 4 weeks. People's usage pattern may change as time goes for a longer period of time. Additionally, the study verified the emotional impact of food message, but didn't include a control condition to examine to what extent the food medium contributed to the feeling. Although participants indicated food would be more emotional than other media in the interviews, it is fairly possible that people might report a similar experience if they receive a message on customized stationary in reality, such as a cup or photo frame. Further studies can be conducted to investigate these issues.

9.3 Closing remarks

This research aimed at exploring how food and technology can be integrated to generate different social experience. My analysis of the communicative affordances of food emphasizes the unique social cues that food provides; recognition of the implications of choices of a particular food over other alternatives; and a focus on how food technologies can reflect the unique advantages to construct food in ways that facilitate social relationships.

Finally, by unpacking the various dimensions of food as a social medium, I have provided implications for envisioned forms of food-based communication. The desire here is not to replace older technologies or to make communications more efficient. Rather, it is for supplementing and enriching the expressive vocabulary of human experience. The ultimate goal is to connect people and transmit affective experience, where food is used as a medium. I hope this dissertation can help to broaden the food-mediated communication, and promote more diverse and multimodal forms of social communication via the food we all enjoy.

Bibliography

1. S. Absolom, A. Roberts. Connecting with Others: The Meaning of Social Eating as an Everyday Occupation for Young People. *Journal of Occupational Science*, 18:4, pp. 339-346, 2011.

2. A. Acar and N. Kimura. Twitter as a Tool for Language Learning: The Case of Japanese Learners of English. In *Special Issue of the International Journal of the Computer, the Internet and Management*, vol. 19, no. SP2, pp. 1-14, 2012.

3. J. Ali, W.-S. Yoon, J.-H. Kim, and W.-D. Cho. U-kitchen: application scenario. In *Software Technologies for Future Embedded and Ubiquitous Systems, 2004. Proceedings. Second IEEE Workshop on*, pp. 169- 171, May 2004.

4. A. K.Amin, B. T. Kersten, A. O. A. Kulyk, P. H. Pelgrim, C. M. Wang, and P. Markopoulos. SenseMS: a user-centered approach to enrich the messaging experience for teens by non-verbal means. In *Proceedings of MobileHCI* '05, pp. 161-166. 2005,

5. D. Anderson. *Chain Codes: An Introduction*. Available: http://www.mind.ilstu.edu/curriculum/modOverview.php?modGUI=162. [Accessed 15January 2012].

6. G. Antos. Handbook of Interpersonal Communication. In *Handbooks of Applied Linguistics Communication Competence Language and Communication Problems Practical Solutions,* Volume 2. Walter De Gruyter, 2008.

7. T. Arakawa, M. Inakage. Mamagoto: "playing" with food. In *ACM SIGGRAPH 2007 Posters*, pp. 161. ACM, 2007.

8. E. Arroyo, V. Righi, R. Tarrago, and J. Blat. A remote multi-touch experience to support collaboration between remote museum visitors. In *Proceedings of the INTERACT'11*, Vol. Part IV. pp. 462-465. Springer-Verlag, 2011.

9. J. N. Bailenson, A. C. Beall. Transformed social interaction: Exploring the digital plasticity of avatars. *Avatars at Work and Play*, pp. 1-16. Springer Netherlands, 2006.

10. J. N. Bailenson, A. C. Beall, J. Loomis, J. Blascovich, & M. Turk. Transformed Social Interaction: Decoupling Representation from Behavior and Form in Collaborative Virtual Environments. *Presence: Teleoperators and Virtual Environments*, 13(4), pp. 428–441, 2004.

11. P. Barden, R. Comber, D. Green, D. Jackson, C. Ladha, T. Bartindale, N. Kinns, T. Stockman, and P. Olivier. Telematic dinner party: designing for togetherness through play and performance. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*. pp. 38-47. ACM, 2012.

12. R. Barthes. Psycho sociology of Contemporary Food Consumption. *From Food and Culture: A Reader*. New York: Routledge, pp. 20-27, 1997.

13. K. Battarbee. Defining co-experience. In *Proceedings of DPPI'03*, pp. 109–113. ACM, 2003.

14. K. Battarbee and E. Kurvinen. Chapter 5 SUPPORTING CREATIVITY – CO-EXPERIENCE. In *Everyday Innovators*, Springer Netherlands, pp. 71–85, 2005.

15. A. Battestini, V. Setlur, and T. Sohn. A large scale study of text-messaging use. In *Proceedings of MobileHCI '10*, pp. 229-238, ACM, 2010.

16. N. Baym. *Personal Connections in the Digital Age*. Polity, April 2010, 196 pages.

17. A. Beardsworth and T. Keil. *Sociology on the menu: An invitation to the study of food and society*. Routledge, 1997.

18. W. Belasco. *Food: The Key Concepts*. Bloomsbury Academic, 224 pages, 2008.

19. G. Bell and J. Kaye. Designing technology for domestic spaces: A kitchen manifesto. *Gastronomica: The Journal of Food and Culture*, 2(2): pp. 46–62, 2002.

20. M.T. Bhömer et al. 4Photos: a collaborative photo sharing experience. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (NordiCHI '10),* pp. 52–61. ACM, 2010.

21. F. Biocca, C. Harms. Defining and measuring social presence: Contribution to the Networked Minds theory and measure. In *Proceedings of PRESENCE 2002*, pp. 7-36.

22. E. Blevis and S. C. Morse. SUSTAINABLY OURS: Food, dude. *Interactions*, vol. 16, no. 2, pp. 58-62, Mar. 2009.

23. M. Blythe, A. Monk, C. Overbeeke, and PC Wright. *Funology: From usability to user enjoyment*, 2003.

24. S. Brave, H. Ishii, and A. Dahley. Tangible interfaces for remote collaboration and communication. In *Proceedings of CSCW '98*. pp. 169-178. ACM, 1998.

25. L. M. Brown and J. Williamson. Shake2Talk : Multimodal Messaging for Interpersonal Communication. In *Haptic and Audio Interaction Design, Proceedings of Second International Workshop, HAID 2007*, pp. 44-55, 2007.

26. M. Buchenau and J. F. Suri. Experience prototyping. In *Proceedings of* DIS '00, pp. 424-433. ACM, 2000.

27. A. V. Cardello, H. Meiselman, H. Schutz et al. Measuring emotional responses to foods and food names using questionnaires. *Food Quality and Preference*, vol. 24, no. 2, pp. 243-250, Jun. 2012.

28. J. Carmigniani, B. Furht, M. Anisetti, P. Ceravolo, E. Damiani, and M. Ivkovic. Augmented reality technologies, systems and applications. *Multimedia Tools and Applications*, 51:pp. 341-377, 2011.

29. N. Charles, M. Kerr. *Women, food and families*. Manchester University Press, 1988.

30. J.-H. Chen, P.-Y. Chi, H.-H. Chu, C.-H. Chen, and P. Huang. A smart kitchen for nutrition-aware cooking. *Pervasive Computing, IEEE*, 9(4): pp. 58 -65, 2010.

31. A.D. Cheok. Art and Technology of Entertainment Computing and Communication. In: *Advances in Interactive New Media for Entertainment Computing*, pp.1-18. Springer, 2010.

32. J. H. Choi, C. Linehan, R. Comber, J. McCarthy. Food for thought: designing for critical reflection on food practices. In *Proceedings of the DIS '12*, pp. 793-794, ACM, 2012.

33. Y. Choi, A. Cheok, V. Halupka, J. Sepulveda, et al. Flavor visualization: Taste guidance in co-cooking system for coexistence. In *Mixed and Augmented Reality - Arts, Media, and Humanities (ISMAR-AMH), 2010 IEEE International Symposium On*, pp. 53-60, 2010.

34. L. Clarkson and M. Crawford. Food, Economy, and Society. In *Feast and Famine: Food and Nutrition in Ireland 1500-1920*, no. June, Oxford University Press, pp. 1–11, 2001.

35. M. Coelho. DinnerWare: why playing with food should be encouraged. In *Proceedings of the CHI 2009 Extended Abstracts*, pp. 3505–3506. ACM, 2009.

36. R. Comber, E. Ganglbauer, J. Choi, J. Hoonhout, Y. Rogers, K. O'Hara, and J. Maitland. Food and interaction design: designing for food in everyday life. In *Proceedings of CHI EA '12*, pp. 2767-2770. ACM, 2012.

37. R. Corr. Reciprocity, Communion, and Sacrifice: Food in Andean Ritual and Social Life. *Food and Foodways*, vol. 10, no. 1-2, pp. 1-25, Jan. 2002.

38. C. M. Counihan. *The anthropology of food and body: Gender, meaning, and power*. New York: Routledge. 1999.

39. S. Counts. Group-Based Mobile Messaging in Support of the Social Side of Leisure. *Computer Supported Cooperative Work (CSCW)*, vol. 16, no. 1-2, pp. 75-97, May 2007.

40. J. M. Cramer, L. M. Walters, and C. P. Greene. *Food as communication / Communication as food*. Peter Lang Publishing, 2011, p. 465.

41. M. Csikszentmihalyi and E. Halton. *The Meaning of Things: Domestic Symbols and the Self*. Cambridge University Press, 1981.

42. R. L. Daft and R. H. Lengel. Information richness. A new approach to managerial behavior and organization design. *Research in Organizational Behaviour*, vol. 6, pp. 191-233, 1984.

43. R. L. Daft and R. H. Lengel. Organizational information requirements, media richness and structural design. *Management Science*, 32 (5), pp. 554-571, 1986.

44. M.L. Dertouzos. *What Will Be: How the New World of Information Will Change Our Lives*. New York: HarperCollins, 1998.

45. P. M. Desmet and H. N. J. Schifferstein. Sources of positive and negative emotions in food experience. *Appetite*, vol. 50, no. 2–3, pp. 290-301, 2008.

46. J. Dewey. *Experience and Nature*. Dover, New York, 1958.

47. J. Dimmick, A. Ramirez, T. Wang, and S.-F. Lin. 'Extending Society': the role of personal networks and gratification-utilities in the use of interactive communication media. *New Media & Society*, vol. 9, no. 5, pp. 795–810, Oct. 2007.

48. M. Douglas. *'Deciphering a Meal', Myth, Symbol and Culture*. MIT Press, New York, pp. 61-81, 1971.

49. P. Dourish. *Where the Action Is: The Foundations of Embodied Interaction.* MIT Press, 2001.

50. W.K. Edwards, V. Bellotti, A.K. Dey, M.W. Newman. Stuck in the middle: the challenges of user-centered design and evaluation for infrastructure. In *Proceedings of CHI'2003*, pp. 297–304. ACM, 2003.

51. L. B. Elizabeth, A. C. Kathleen, F. H. Robert. Patterns of Dinnertime Interaction in Divorced and Non-Divorced Families. *Journal of Divorce and Remarriage*, 32:3-4, pp. 125-139. 2000.

52. Y. Engeström. *Learning by expanding: an activity-theoretical approach to developmental research.* Orienta-Konsultit Oy., Helsinki, 1987.

53. D. Fallman. Design-oriented human-computer interaction. In *Proceedings of the CHI '03*, pp. 225-232, ACM, 2003.

54. D. Fallman. The new good: exploring the potential of philosophy of technology to contribute to human-computer interaction. In *Proceedings of the CHI '11*, pp. 1051-1060. ACM, 2011.

55. P. Farb, G. Armelagos. *Consuming passions: The anthropology of eating*. Boston: Houghton Mifflin. 1980.

56. J. Finkelstein. The Taste of Boredom: McDonaldization and Australian Food Culture.

American Behavioral Scientist, 47(2), pp. 187 – 200, 2003.

57. C. Fischler. Food, self and identity. *Social Science Information*, volume 27(2), pp. 275-292, 1988.

58. Z. Foley-Fisher, V. Tsao, J. Wang, S. Fels. Netpot: Easy meal enjoyment for distant diners. In *Proceedings of ICEC 2010, Lecture Notes in Computer Science*, LNCS: volume 6243, pp. 446–448, 2010.

59. J. Forlizzi and K. Battarbee. Understanding experience in interactive systems. In *Proceedings of DIS '04*, pp. 261-268. ACM, 2004.

60. J. Freyne and S. Berkovsky. Intelligent food planning: personalized recipe recommendation. In Proceedings of IUI '10, pp. 321-324, ACM, 2010.

61. S. Fukuda. Ed. *Emotional Engineering: Service Development*, Springer, 2010.

62. T. Furst, M. Connors, J. Sobal, C. Bisogni, and L. W. Falk. Food classifications: Levels and categories. *Ecology of Food and Nutrition*, vol. 39, no. 5, pp. 331–355, Oct. 2000.

63. K. M. Galvin and B. J. Brommel. *Family communication: Cohesion and change.* Scott, Foresman and Company, Glenview, IL, 1982.

64. E. Ganglbauer, G. Fitzpatrick, and R. Comber. Negotiating food waste: Using a practice lens to inform design. *ACM Transactions on Computer-Human Interaction*, vol. 20, no. 2, pp. 1-25, May 2013.

65. D. Gooch. Socialising presence. In *Proceedings of CHI extended abstracts* 2011, pp. 1049-1052, ACM, 2011.

66. P. G. Grant. Food for the soul: Social and Emotional Origins of comfort eating in the Morbidly Obese. In *Psychological Responses to Eating Disorders and Obesity: Recent and Innovative Work*, pp. 121-137, 2008.

67. A. Grimes, R. Harper. Celebratory technology: new directions for food research in HCI. In *Proceeding of CHI 2008*, pp. 467 – 476. ACM, 2008.

68. R. Grinter and M. Eldridge. y do tngrs luv 2 txt msg?. In *Proceedings of ECSCW'01*, pp. 219-238, 2001.

69. R. Grinter and M. Eldridge. Wan2tlk?: everyday text messaging. In *Proceedings of CHI '03*, pp. 441-448, ACM, 2003.

70. J. M. Gutteling, O.Wiegman. Risk Communication Media. In *Exploring Risk Communication: Advances in Natural and Technological Hazards Research*, vol 8, pp. 170-182, 1996.

71. R. Hamada, J. Okabe, I. Ide, S. Satoh, S. Sakai, and H. Tanaka. Cooking navi: assistant for daily cooking in kitchen. In *Proceedings of MULTIMEDIA '05*, pp. 371–374. ACM, 2005.

72. C. A. C. Happel. You are what you eat: Food as expression of social identity and intergroup relations in the colonial Andes. *Cincinnati Romance Review*, 33, 10 (2012), 175-193.

73. Y. Hård. Language in SMS - a socio-linguistic view. In *The Inside Text: Social , Cultural and Design Perspectives on SMS*, vol. 4, R. Harper, L. Palen, and A. Taylor, Eds. pp. 33-51, 2005.

74. C. Harms and F. Biocca. Internal consistency and reliability of the networked minds social presence measure. *Presence Workshop*, 2004.

75. R. Harper. Towards a new Communications Genre. *IEEE Computer On-Line Magazine*, pp. 99-101, 2005.

76. R. Harper, S. Hodges. Beyond talk, beyond sound: Emotional expression and the future of mobile connectivity. In: J. Höflich, M. Hartmann (eds.) *Mobile Communication in Everyday Life: An Ethnographic View*, Frank & Timme, 2006.

77. R. Harper. *The Connected Home: The Future of Domestic Life.* Springer-Verlag London, 2011.

78. R. Harper. *Texture: Human Expression in the Age of Communications Overload*. MIT press, London, 2010.

79. S. Harrison, D. Tatar, and P. Sengers. The three paradigms of HCI. In *Alt. Chi. Session at the CHI'07*, ACM, 2007.

80. M. Hassenzahl, S. Heidecker, K. Eckoldt, S. Diefenbach, and U. Hillmann. All You Need is Love: Current Strategies of Mediating Intimate Relationships through Technology. In *ACM Transactions on Computer-Human Interaction*, vol. 19, no. 4, pp. 1–19, Dec. 2012.

81. T. Hirsch, P. Sengers, E. Blevis, R. Beckwith, and T. Parikh. Making food, producing sustainability. In *Proceedings of the CHI' 2010 Extended Abstracts*, pp. 3147‑3150. ACM, 2010.

82. W.A. IJsselsteijn, J.v.Baren, F.v.Lanen. Staying in Touch: Social Presence and Connectedness through Synchronous and Asynchronous Communication Media. In *Human-Computer Interaction: Theory and Practice (Part II)*, pp. 924-928, 2003.

83. D. Inglis, D. Gimlin, C. Thorpe. *Food: Critical concepts in the social sciences*. Routledge, 2099 pages, 2007.

84. K. Inkpen, H. Du, A. Roseway, A. Hoff, and P. Johns. Video kids: augmenting close friendships with asynchronous video conversations in videopal. In *Proceedings of CHI '12*, pp. 2387-2396, ACM, 2012.

85. T. Inoue. Iterative Design of Adaptive Tabletop Dish Recommendation by Real-time Recognition of Dining Status. *International Journal of Informatics Society.* Volume 4, No. 1, pp. 51-58, 2012.

86. M. Irwin. Caramel-Pumping 3D Fabricator Has Couple on a Sugar High. *Wired Magazine*. July 24. 2007.

87. Y. Itoh, A. Miyajima, and T. Watanabe. 'TSUNAGARI' communication: fostering a feeling of connection between family members. In *CHI '02 Extended Abstracts on Human Factors in Computing Systems*. pp. 810-811, ACM, 2002.

88. T. K. Judge, C. Neustaedter, and A. F. Kurtz. The family window: the design and evaluation of a domestic media space. In *Proceedings of the CHI '10*, pp. 2361-2370. ACM, 2010.

89. J. J. Kalanithi and V. M. Jr. Bove. Connectibles: tangible social networks. In *Proceedings of TEI '08*. pp. 199-206. ACM, 2008.

90. E. Kasesniemi, P. Rautiainen. Mobile Culture of Children and Teenagers in Finland. In: J.E.Katz, M.A. Aakhus (eds.) *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, pp. 170-192. Cambridge University Press, 2002.

91. N. Kime. Changes in Intergenerational Eating Patterns and the Impact on Childhood Obesity. *Health Education Journal*, 71 (2), pp. 173-179, 2012.

92. S. C. King, H. L. Meiselman. Development of a method to measure consumer emotions associated with foods. Food Quality *and Preference*, volume 21(2), pp.168-177, 2010.

93. B. Kirthenhlatt-Gimlilelt. Playing to the Senses: Food as a Performance Medium. *Performance Research*, vol. 4, no. 1, pp. 1-30, 1999.

94. E. A. Konijn, S. Utz, M. Tanis, and S. B. Barnes, *Mediated Interpersonal Communication*. Routledge, pp. 402, 2008.

95. T. Kopomaa. The breakthrough of text messaging in Finland. In: R. Harper, L. Palen, A. Taylor. (eds.) The *Inside Text: Social, Cultural and Design Perspectives on SMS*, Springer, Heidelberg, 2005.

96. Ann M. Kring, Albert H. Gordon. Sex differences in emotion: Expression, experience, and physiology. *Journal of Personality and Social Psychology*, Volume 74 (3), pp. 686-703, March 1998.

97. A. Krishna. An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior. *Journal of Consumer Psychology*, Oct. 2011.

98. J. Laaksolahti. Plot, spectacle, and experience: Contributions to the design and evaluation of interactive storytelling. Doctoral thesis, Computer and System Science, Stockholm University, 2001.

99. G. Lakoff and M. Johnson. *Metaphors We Live By*. University of Chicago Press, 1980.

100. J. Lazar, J. H. Feng, H. Hochheiser. *Research Methods in Human-Computer Interaction*. 2009.

101. W. Leeds-Hurwitz. *Semiotics and Communication: Signs, Codes, Cultures*. Taylor & Francis, 1993.

102. T. W. Leong, F. Vetere, and S. Howard. Experiencing coincidence during digital music listening. *ACM Transactions on Computer-Human Interaction (TOCHI),* 19, 1, Article 6, pp. 6:1--6:19. May 2012.

103. H. Li, H. Zheng, and Y. Wang. Segment Hough Transform – a Novel Hough-based Algorithm for Curve Detection. In *4th International Conference on Image and Graphics*, 2007.

104. Y. Li, J.A. Landay. Into the wild: low-cost ubicomp prototype testing. *IEEE Computer,* 41(6), pp. 94-97. June 2008.

105. R. Ling, T. Julsrud, B. T. Yttri. Nascent communication genres within SMS and MMS. In *The Inside Text: Social perspectives on SMS in the mobile age*, Springer Netherlands, pp. 75-100, 2005.

106. J.I. Lipton, D. Arnold, F. Nigl, N. Lopez, D.L.Cohen, N. Noren, H. Lipson. Multi-Material Food Printing with Complex Internal Structure Suitable for Conventional Post-Processing. In *Proceedings of SFF'10*, pp. 809-815, 2010.

107. J.-L. Lo, T.-y. Lin, H.-h. Chu, H.-C. Chou, J.-h. Chen, J.Y.-j. Hsu, P. Huang. Playful Tray: Adopting Ubicomp and Persuasive Techniques into Play-Based Occupational Therapy for Reducing Poor Eating Behavior in Young Children. In *Krumm, J., Abowd, G.D., Seneviratne, A., Strang, T., et al. (eds.) UbiComp 2007*. LNCS, vol. 4717, pp. 38–55. Springer, 2007.

108. J. L. Locher, W. C. Yoels, D. Maurer, and J. V. Ells. Comfort Foods: An Exploratory Journey into the Social and Emotional Significance of Food. *Food and Foodways*, vol. 13, no. 4, pp. 273-297, Oct. 2005.

109. D. Lupton. *Food, the Body and the Self*. London: SAGE Publications Ltd., 1998.

110. D. Ma, F. Ichikawa, Y. Liu, and L. Jiang. Use of Chinese Short Messages. In *Human Interface, Part II, HCII,* vol. 10, no. 10, pp. 582-591, 2007.

111. E. Malone and H. Lipson. Fab@Home: The Personal Desktop Fabricator Kit. *Rapid Prototyping Journal*, pp. 245-255, 2007.

112. L. D. Manning. Exploring the Recursive Nature of Food and Family Communication. *Communication Teacher*, vol. 20, No. 1, pp. 1-5. January 2006.

113. M. Martin. *Encyclopedia of Community: From the Village to the Virtual World*, edited by Karen Christensen and David Levinson, pp. 502-505. Thousand Oaks, CA: SAGE Publications, Inc., 2003.

114. P.A. Mayer. Computer Media Studies: an Emergent Field. In P.A. Mayer (ed.) *Computer Media and Communication: A Reader*, pp. 320-336. Oxford: University Press. 1999.

115. D. Maynes-Aminzade. Edible bits: Seamless interfaces between people, data and food. In *Proc. of CHI'05-Extended Abstracts*, pp. 2207-2210. ACM, 2005.

116. J. McCarthy and P.Wright. *Technology as Experience*, 2004.

117. M. McLuhan. *Understanding Media The extensions of man*. Routledge & Kegan Paul.1964.

118. J.M. Metz. Computer-mediated communication: Literature review of a new context. *Interpersonal Computing and Technology*, 2 (2), pp. 31－49, 1994.

119. F. Mueller, F. Vetere, M. R. Gibbs, J. Kjeldskov, S. Pedell, and S. Howard. Hug over a distance. In *CHI '05 Extended Abstracts*, pp. 1673-1676, ACM 2005.

120. F. Mueller, F. Vetere, M. Gibbs, D. Edge, S. Agamanolis, J. Sheridan, and J. Heer. Balancing exertion experiences. In *Proceedings of the CHI '12*, pp. 1853-1862. ACM, 2012.

121. E. D. Mynatt, J. Rowan, S. Craighill, and A. Jacobs. Digital family portraits: supporting peace of mind for extended family members. In *Proceedings of the CHI '01*, pp. 333-340. ACM, 2001.

122. H. Nakamura and H. Miyashita. Augmented gustation using electricity. In *Proceedings of the 2nd Augmented Human International Conference on - AH '11*, pp. 1–2, ACM, 2011.

123. H. Nakamura and H. Miyashita. Development and evaluation of interactive system for synchronizing electric taste and visual content. In *Proceedings of CHI '12*, pp. 517-520, ACM, 2012.

124. H. Nakamura and H. Miyashita. Communication by change in taste. In *Proceedings of CHI EA '11*, pp. 1999–2004, ACM, 2011.

125. Y. Nakauchi, T. Suzuki, A. Tokumasu, and S. Murakami. Cooking procedure recognition and inference in sensor embedded kitchen. In *Proceedings of RO-MAN 2009*, pp. 593 –600, 2009.

126. M. Nawahdah, T. Inoue. Virtually dining together in time-shifted environment: KIZUNA design. In *Proceedings of the CSCW '13*, pp. 779-788. ACM, 2013.

127. S. Neely, G. Stevenson, C. Kray, I. Mulder, K. Connelly, K.A. Siek. Evaluating pervasive and ubiquitous systems. *IEEE Pervasive Computing,* 7(3), pp. 85–88, 2008.

128. D.A. Norman. *Emotional design: Why we love (or hate) everyday things.* 2004.

129. D.A. Norman. *The Design of Everyday Things*. New York, 1988.

130. P. Olivier, G. Xu, A. Monk, and J. Hoey. Ambient kitchen: designing situated services using a high fidelity prototyping environment. In *Proceedings of PETRA '09*, pp. 47:1-47:7. ACM, 2009.

131. J. Ornbo, C. Sneppen, and P. F. Würtz. *Experience-Based Communication*, 273 pages. Springer Berlin Heidelberg, 2008.

132. K. O'Hara, J. Helmes, A. Sellen, R. Harper, et al. Food for Talk: Phototalk in the Context of Sharing a meal. *Human-Computer Interaction*, 27:1-2, pp. 124-150, 2012.

133. F. Parasecoli. Savoring semiotics: food in intercultural communication. *Social Semiotics*, vol. 21, no. 5, pp. 645-663, Nov. 2011.

134. E. Paulos. Connexus: a communal interface. In *Proceedings of the 2003 conference on Designing for user experiences (DUX '03)*. pp. 1-4, ACM, 2003.

135. R. L. Peiris, A. D. Cheok, J. K. S. Teh, O. N. N. Fernando, W. Yingqian, A. Lim, P. Yi, D. Polydorou, K. P. Ong, and M. Tharakan. Ambikraf: an embedded non-emissive and fast changing wearable display. In *ACM SIGGRAPH '09 Emerging Technologies*, pp. 1:1–1:1, ACM, 2009.

136. D. Periard, N. Schaal, M. Schaal, E. Malone, H. Lipson. Printing Food. In *Proceedings of SSF '07*, pp.564-574, 2007.

137. M. Perry and D. Rachovides. Entertaining situated messaging at home. *Computer Supported Cooperative Work (CSCW)*, vol. 16, no. 1-2, pp. 99-128, Apr. 2007.

138. A. Perttula, P. Tuomi, M. Suominen, A. Koivisto, and J. Multisilta. Users as sensors: creating shared experiences in co-creational spaces by collective heart rate. In *Proceedings of the MindTrek '10*. pp. 41-48. ACM, 2010.

139. T.Y. Phillips and A. Rosenfeld. A method for curve partitioning using arc-chord distance. *Pattern Recognition Letters*, 5 (1987), pp. 285–288.

140. B. Pietrykowski. You Are What You Eat: The Social Economy of the Slow Food Movement. *Review of Social Economy*, vol. 62, no. 3, pp. 307-321, Sep. 2004.

141. O. Pikalo. Latte art machine. In *ACM SIGGRAPH 2008 new tech demos on - SIGGRAPH '08*, pp. 1-1.ACM, 2008.

142. B.J. Pine, J.H. Gilmore, et al. *The experience economy*. Harvard Business School Press Boston, MA, 1999.

143. P. Pliner, S. Chaiken. Eating, Social Motives, and Self-presentation in Women and Men. *Journal of Experimental Social Psychology*, 26, pp. 240-254, 1990.

144. R. Poínhos, B. M. P. M. Oliveira, & F. Correia. Eating behaviour patterns and BMI in Portuguese higher education students. *Appetite*, 71, pp. 314–320, 2013.

145. P. Polotti et al. Gamelunch: forging a dining experience through sound. In *Proceedings of the CHI 2008 Extended Abstracts*, pp. 2281‑2286. ACM, 2008.

146. N. Postman. *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*. USA: Penguin. 1985.

147. E. Probyn. *Carnal appetites: FoodSexIdentities*. London: Routledge. 2000.

148. S.A. Quandt et al. The social and nutritional meaning of food sharing among older rural adults. *Journal of Aging Studies*, 15(2), pp. 145‑162, 2001.

149. H. Rae-Espinoza. Family mealtime as a context of development and socialization. *New directions for child development*, No. 111, 38(1):1–3. Wiley periodicals, 2006.

150. H. Raffle, R. Ballagas, G. Revelle, K. Mori, H. Horii, C. Paretti, and M. Spasojevic. Pop goes the cell phone: asynchronous messaging for preschoolers. In *Proceedings of IDC '11*, pp. 99-108. ACM, 2011.

151. J. Redstrm. Designing everyday computational things. *Gothenburg Studies in Informatics*, no. 20, Dept. of Informatics, Gothenburg University, 2001.

152. R. E. Rice. Media Appropriateness: Using Social Presence Theory to Compare Traditional and New Organizational Media. *Human Communication Research*, volume19 (4), pp. 451-484, 1993.

153. M. a. Riordan and R. J. Kreuz. Cues in computer-mediated communication: A corpus analysis. *Computers in Human Behavior*, 26, 6 (2010), pp. 1806-1817.

154. N. Romero, P. Markopoulos, J. Baren, B. Ruyter, W. Ijsselsteijn, and B. Farshchian. Connecting the family with awareness systems. *Personal and Ubiquitous Computing*. Volume 11, 4 (April), pp. 299-312. 2007.

155. S. Salvy, D. Jarrin, R. Paluch, N. Irfan, P. Pliner. Effects of social influence on eating in couples, friends and strangers. *Appetite*, 49(1), pp. 92–99, 2007.

156. H. Sharp, Y. Rogers, and J. Preece. *Interaction Design: Beyond Human Computer Interaction*. John Wiley & Sons, 2007.

157. J. Short, E. Williams, and B. Christie. *The social psychology of telecommunications*. London, Wiley, 1976.

158. M. Snyder, J. Zimmerman, and J. Forlizzi. Your dinner's calling: supporting family dinnertime activities. In *Proceedings of DPPI '07*, pp. 485–489. ACM, 2007.

159. L. Sullivan (Ed.).Communication medium. In *The SAGE glossary of the social and behavioral sciences.* pp. 90. Thousand Oaks, CA: SAGE Publications, Inc. 2009.

160. L. Tang, Z. Yu, X. Zhou, H. Wang, and C. Becker. Supporting rapid design and evaluation of pervasive applications: challenges and solutions. *Personal and Ubiquitous Computing*, pp. 253-269, 2011.

161. A. Taylor, R. Harper. Age-old Practices in the 'New World': A study of gift-giving between teenage mobile phone users. In *Proc. of CHI '02*, pp. 439-446, 2002.

162. K. Tee, a. J. B. Brush, and K. M. Inkpen. Exploring communication and sharing between extended families. *International Journal of Human-Computer Studies*, vol. 67, no. 2, pp. 128-138, Feb. 2009.

163. L.K. Trevino, R.K. Lengel, R.L. Daft. Media Symbolism, Media Richness and media Choice in Organizations. *Communication Research*, 14(5), pp. 553-574, 1987.

164. L.K. Treviño, J. W. and E. W. Stein. Making Connections: Complementary Influences on Communication Media Choices Attitudes, and Use. *Organization Science*, Vol. 11, No. 2 (Mar. – Apr., 2000), pp. 163-182.

165. H. Tsujita, S. Yarosh, and G. D. Abowd. CU-Later: a communication system considering time difference. In *Proceedings of the Ubicomp '10 Adjunct*, pp. 435-436. ACM, 2010.

166. T. Tullis and B. Albert. Chapter 6 - Self-Reported Metrics. In *Measuring the User Experience*. pp. 123-166. Morgan Kaufmann, San Francisco, 2008.

167. D. Uriu, M. Namai, S. Tokuhisa, R. Kashiwagi, M. Inami, and N. Okude. panavi: recipe medium with a sensors-embedded pan for domestic users to master professional culinary arts. In *Proceedings of the CHI '12*, pp. 129-138. ACM, 2012.

168. M. Weiser. The Computer for the 21st Century. In *Scientific American*, pp. 94 September 1991.

169. M. F. Wolfinbarger, M. C. Gilly. The Relationship of Gender to Gift-Giving Attitudes. *Gender and Consumer Behavior*, vol. 1, pp. 223-233, 1991.

170. L. Yao, S. Dasgupta, N. Cheng, J. Spingarn-Koff, O. Rudakevych, and H. Ishii. Rope Revolution: tangible and gestural rope interface for collaborative play. In *Proceedings of the ACE '11*, Article 11, 8 pages, ACM, 2011.

171.   S. Yarosh, S. Cuzzort, H. Müller, and G. D. Abowd. Developing a media space for remote synchronous parent-child interaction. In *Proceedings of the IDC '09*, pp. 97-105, ACM, 2009.

172.   A. Zoran and M. Coelho. Cornucopia: The Concept of Digital Gastronomy. Leonardo, vol. 44, no. 5, pp. 425-431, Oct. 2011.

Appendix A

Survey of CoDine

I. Personal Info

1. Gender:

- o Male
- o Female

2. Age:

- o < 25 years old
- o 25-35 years old
- o 36-45 years old
- o 46-55 years old
- o >65 years old

3. Marital status:

- o Single
- o Married
- o Divorced
- o Other

4. I live together with my family:

- o Yes
- o No

5. Nationality:

  _____

6. On average, how many hours you spend together with your family?

_____ Hours/week

7. Basic Info about family dinner (Please tick the one that applies to you)

Descriptions	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree
I used to have dinner with my family regularly a few years ago.					
I have dinner with my family everyday currently.					
I desire to have dinner with my family every day.					
Family dinner is very important for my family relationship.					
I feel much happier when having dinner with my family.					
Family dinner is an important social activity.					
Family dinner is an					

important cultural tradition.					

II. Feedback for the CoDine system (Please tick the one that applies to you)

Descriptions: **Co-dining: experience of having dinner together even in remote locations.**	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree
Overall system					
It achieves to provide the experience of co-dining remotely.					
It is helpful to increase family bonding when people are away from each other.					
It enhances the engagement experience between co-diners.					
It enhances the sense of "being together" through tangible interactions.					
It supports the traditional cultural experience during family dining.					
It provides natural interactions under family dinner context.					
1- Hosting Table					
It contributes to provide the experience of co-dining.					
It enhances engagement experience between co-diners.					
It enhances the sense of "being together" through tangible interactions.					
It supports the cultural experience during family dining.					
It provides natural interactions over family dinner.					
2- Ambient Tablecloth					
It contributes to provide the experience of co-dining.					
It enhances engagement experience between co-diners.					

It enhances the sense of "being together" through tangible interactions.					
It supports the cultural experience during family dining.					
It provides natural interactions over family dinner.					
3- Food Teleportation					
It contributes to provide the experience of co-dining.					
It enhances engagement experience between co-diners.					
It enhances the sense of "being together" through tangible interactions.					
It supports the cultural experience during family dining.					
It provides natural interactions over family dinner.					
4- Interaction Screen					
It is natural and easy to use and enhances the intuitiveness of the system.					
It increases the playfulness and engagement experience between co-diners.					

Feedback or Suggestion

e.g. How can the current system be improved?

What other dinner activity can be included in this system?

Contact us: weijun@cutecenter.org

Appendix B

Empirical Study: Sender Survey

❖ All information will be kept confidential and for research purpose only.

1. Personal Information

Is this your first time using Food Messaging?

o Yes

o No

If yes, your email *:

_____

Gender *： Female/ Male

Age *：

o <20

o 20-29

o 30-39

o 40-50

o >50

Marital Status *:

o Single

o Married

o Others

Profession *

_____

2. Messaging Experience

Your relationship with the receiver *

o Parent/Child

o Husband/Wife

o Relative

o Boy/Girlfriend

o Good Friend

o Colleague

o   Someone I know

o   Others

Please select the emotional type of your message *

o   Positive

o   Neutral

o   Negative

Please tick the one that most suit with your opinion *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The edible medium can convey my emotional feeling beyond textual meanings.	○	○	○	○	○
2. I think this way of communication is interesting and fun.	○	○	○	○	○
3. I use this way to send social message just for fun.	○	○	○	○	○
4. I use this way to send social message because of its specialty.	○	○	○	○	○
5. I use this way to send social message to impress the receiver.	○	○	○	○	○
6. I think this way of communication can enhance the intimacy between us.	○	○	○	○	○

Do you want to use this service again?

o   Yes

o   No

Empirical Study: Receiver Survey

❖ All information will be kept confidential and for research purpose only.

1. Personal Information

ID *_____

Gender *：Female/ Male

Age *：

o <20

o 20-29

o 30-39

o 40-50

o >50

Marital Status *:

o Single

o Married

o Others

Profession *

_____

2. Messaging Experience

Please select the emotional type of your message *

o Positive

o Neutral

o Negative

Please tick the one that most suit with your opinion *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I can feel the sender's emotion from the edible message.	○	○	○	○	○
2. I think this way of communication is interesting and fun.	○	○	○	○	○
3. The edible message creates a feeling of importance about myself.	○	○	○	○	○

4. The emotional feeling mainly comes from the color of message.	○	○	○	○	○
5. The emotional feeling mainly comes from the smell of message.	○	○	○	○	○
6. I would like to eat the message.	○	○	○	○	○
7. Eating this message would make me much happier if the message is sweet.	○	○	○	○	○
8. I am impressed by the edible message.	○	○	○	○	○
9. I think this way of communication can enhance the intimacy between us.	○	○	○	○	○

Empirical Study: Overview of sender ratings

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The edible medium can convey my emotional feeling beyond the textual meanings.	58.95% (530)	24.81% (223)	10.79% (97)	0.22% (2)	5.23% (47)
2. I think this way of communication is interesting and fun.	67.41% (606)	19.02% (171)	7.90% (71)	0.78% (7)	4.89% (44)
3. I use this way to send social message just for fun.	39.04% (351)	24.92% (224)	18.58% (167)	11.12% (100)	6.34% (57)
4. I use this way to send social message because of its specialty.	63.96% (575)	22.25% (200)	8.57% (77)	0.33% (3)	4.89% (44)
5. I use this way to send social message to impress the receiver.	58.84% (529)	22.69% (204)	12.35% (111)	1.11% (10)	5.00% (45)
6. I think this way of communication can enhance the intimacy between us.	57.17% (514)	22.58% (203)	13.79% (124)	1.11% (10)	5.33% (48)
				Total Respondents	**899**

Empirical Study: Overview of Receiver ratings

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I can feel the sender's emotional feeling from the edible message.	61.35% (446)	31.64% (230)	4.68% (34)	0.83% (6)	1.51% (11)
2. I think this way of communication is interesting and fun.	65.47% (476)	30.26% (220)	2.48% (18)	0.69% (5)	1.10% (8)
3. The edible message creates a feeling of importance about myself.	57.36% (417)	33.70% (245)	7.15% (52)	0.69% (5)	1.10% (8)
4. The emotional feeling mainly comes from the color of message.	49.66% (361)	32.60% (237)	13.48% (98)	2.75% (20)	1.51% (11)
5. The emotional feeling mainly comes from the smell of message.	49.93% (363)	33.29% (242)	12.52% (91)	3.03% (22)	1.24% (9)
6. I would like to eat the message.	46.49% (338)	26.69% (194)	11.14% (81)	11.28% (82)	4.4% (32)
7. Eating this message would make me feel much happier if the message is sweet.	61.62% (448)	28.47% (207)	5.91% (43)	2.48% (18)	1.51% (11)
8. I am impressed by the edible message.	66.99% (487)	27.65% (201)	3.44% (25)	0.14% (1)	1.79% (13)
9. I think this way of communication can enhance the intimacy between us.	65.47% (476)	26.41% (192)	5.09% (37)	1.38% (10)	1.65% (12)
				Total Respondents	**727**

Empirical Study: Follow-up Interview Questions

1) How did you know about this? First sent or received a message? What motivated you to participate? What was your first response?

2) Did you remember your first sender/receiver? Have you talked to the sender/receiver about this? What's their impression? Does this affect your relationship with that person?

3) What motivated you to (not) do it again?

4) What kinds of SNS you use in daily life? (Frequency, content, relationships, context)

5) Nowadays there are many ways for social messaging, such as SMS, wechat, IM, letter, in your opinion, what are the differences between them? (About perceived feeling)

6) In your view, what's unique about food among these media types?

7) Why you choose to send message using food instead of other media such as SMS or letters?

8) Will you change the content of the message depending on the type of media you use?

9) For example, when using food for social messages, will your content, expressions, length of messages change? What about usage frequency and context?

10) How will you choose the receivers? Who will you send first? And why?

11) Do you think food messaging is different from food gifting, or other personalized gifts (e.g. cup with your name/photo)? If yes, why?

12) Did you face any problem in using it?

13) Have you heard this before? Have you ever used food for social messages?

14) Will you use it in the future? How are you planning to use it? Do you think it would replace current ways, or a complement?

15) In what situations will you use it? In what situations, you will not use it?

16) What is your wish list if a future system will be designed? (e.g. functions, interface, appearance, cost, etc)

17) Others (maybe more details about their usage scenarios)

Appendix C

List of Publication

- **Jun Wei**, Xiaojuan Ma, Shengdong Zhao. Food Messaging: Using an Edible Medium for Social Messaging. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI'14)*, pp. 2873-2882, ACM, 2014.

- **Jun Wei** et al. Food Messaging: How Edible Medium can Specialize Social Communication. *Entertainment Computing*. (In Revision)

- **Jun Wei,** S. Zhao. Food Media: Support Social and Cultural Experience through Technologically-enhanced Food Interaction. In *Proceedings of Chinese CHI 2013*. Paris, France.

- **Jun Wei**, et al. Food Media: Exploring Interactive Entertainment over Telepresent Dinner. *Computers in Entertainment (CIE)*, 2013. (Accepted)

- X. Wang, E. T. Khoo, **Jun Wei**, A. D. Cheok. Reviving Traditional Chinese Culture through An Interactive Chat Application. *Computers in Entertainment (CIE)*, 2013. (Accepted)

- **Jun Wei**, A. D. Cheok, R. Nakatsu. Let's Have Dinner Together: Evaluate the Mediated Co-dining Experience. In *Proceedings of 14th ACM International Conference on Multimodal Interaction* (ICMI '12). ACM, pp. 225-228.

- **Jun Wei**, A. D. Cheok. Foodie: play with your food Promote interaction and fun with edible interface. *Consumer Electronics, IEEE Transactions on*, vol. 58, no. 2, pp. 178 - 183, 2012.

- **Jun Wei** and R. Nakatsu. Leisure Food: Derive Social and Cultural Entertainment through Physical Interaction with Food. In *Proceedings of Entertainment Computing - ICEC 2012,* LNCS Vol. 7522, pp. 256-269, 2012.

- **Jun Wei,** S. Zhao, R. Nakatsu, H. Duh. When AR Meets Food: A Structural Overview of the Research Space on Multi-Facets of Food. In *Proceeding of International Symposium on Mixed and Augmented Reality (ISMAR-AMH)*, pp. 97-98, 2012.

- N. Chu, Y. Choi, **Jun Wei**, A. D. Cheok, Games Bridging Cultural Communications. In *Proceedings of IEEE Global Conference on Consumer Electronics (GCCE 2012*), pp. 329-332, 2012.

- A. D. Cheok, N. Chu, Y. Choi, **Jun Wei.** Games Bridging Cultural Communications. In *Proceedings of Advances in Computer Entertainment (ACE'12), LNCS*, Volume 7624, pp. 421-428. Springer, 2012.

- **Jun Wei**, X. Wang, R. L. Peiris, et al. CoDine: An Interactive Multi-sensory System for Remote Dining. In *Proceedings of the 13th international conference on Ubiquitous computing* (UbiComp '11). ACM, pp. 21-30. (Acceptance rate 50/302=16.6%)

- **Jun Wei**, A. D. Cheok, X. R. Marinez, R. Tache, Q. Zhu. (2011) Foodie: Play with your food Extend social cooking game with novel edible interface. In *Games Innovation Conference (IGIC), 2011 IEEE International,* pp. 59-61.

- **Jun Wei**, R. L. Peiris, Jeffrey T. K. V. Koh, et al. Food Media: Exploring Interactive Entertainment over Telepresent Dinner. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology* (ACE '11), 26:1-26:8, ACM.

- **Jun Wei**, A. D. Cheok, X. Roman, et al. FoodGenie: Play with your food. In *SIGGRAPH Asia 2011 Emerging Technologies* (SA '11). ACM, Article 23.

- **Jun Wei**. Food Media-Communication beyond technology, In *Ambient Assisted Living Forum - YR-RISE workshop*, Denmark, Sep 2010. (Poster)

- Yongsoon Choi, A. D. Cheok, V. Halupka, J. Sepulveda, R. Peris, J. Koh, Wang X., **Wei Jun**, A. Dilrukshi, Y. Tomoharu, M. Kamata, D. Kato, and K. Yamada. Flavor Visualization: Taste Guidance in Co-cooking System for Coexistence. *ISMAR-AMH, 2010*, pp. 53-60, IEEE Publication.