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Ying-Yu Chen

Designing Playful Technology for Young Children's Mealtime

Ying-Yu Chen

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Reading Committee:

Daniela Rosner, Co-Chair

Alexis Hiniker, Co-Chair

Julie Kientz,

Jaime Snyder.

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University of Washington

Abstract

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Ying-Yu Chen

Co-Chair of the Supervisory Committee:

Associate Professor, Daniela Rosner
Human Centered Design and Engineering
Assistant Professor, Alexis Hiniker
Information School

This dissertation examines the role technology plays in various relationships between parents and young children at family mealtimes, which constitutes a recurring routine in family lives. Mealtimes are important for young children's nutritional intake, and for providing them with ways to learn healthy eating habits and good table manners. However, their food pickiness and mealtime tantrums are also a source of parents' stress. There is potential for technology solutions to support young children's and families' mealtime practices, but there is also the potential for such solutions to be rejected because of the general parent's rejection of technology in this context. Thus, it embodies the potential paradox technology brings to family dynamics.

The study began by building a formative understanding of young children's mealtime practices both in preschool classrooms and in their homes. Participant observation was used to gain insights into the values of children and their adult caretakers, and how they express them through their shared mealtimes. The value tensions between children and adults, and the parents' mealtime goals were identified in that context.

Based on what was learned in this formative work, a speculative design survey was used to understand the parents' perspectives on technology at mealtimes. Thus, 12 storyboards were designed, one for each unique combination of technology type and mealtime goals, and created a survey tool depicting all 12 scenarios for 122 parents of preschoolers. The results identified the unique ways in which each of these form factors appeals to and worries parents, providing designers with insights about the likelihood of adoption and acceptance.

Drawing on the results from these studies, three prototypes were designed to address different value tensions (e.g., the tension between children's interest in experimenting with food versus the teachers' interest in cleanliness). The prototypes were then evaluated with the children, their parents, and teachers in laboratory studies. The results show technology has the potential to enhance shared meals between children and adults, but it also has the potential to distract or influence children in inappropriate ways. The findings suggest the opportunities for novel designs to provide creative and meaningful experiences, such as playful productivity, that support the needs of both stakeholders.

Based on the knowledge learned in previous studies, a smart object, the "stamp plate", was developed. Deploying a prototype in a field study enabled parents to guide their children to explore ideas of data concepts, and it functioned as a tool to aid in teaching numeracy skills. While using the stamp plate, children also ate more and engaged in exploratory art expression with their family

members. The study's results demonstrate how activities, such as family bonding, play, learning, and togetherness, might be supported through the use of a novel technology.

This dissertation examines the properties of technological tools to be used or conceived of for young children's family routines that aim to foster meaningful experiences and rich interactions. It contributes to the investigations of how children's technology use at home has emerged as an ongoing engagement with their life routines, and how designing for this process of engagement can address the values of children and their parents. It is hoped that the design outcomes and insights can be expanded to inform the everyday integration of smart objects into the family lives of children, to inform the design of further technological tools so developers will consider the complexity of the relationship between technology and the routines of family life.

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DEDICATION

To my family,
for their constant support and unconditional love.

Chapter 1. INTRODUCTION

Meals are an important part of daily routines for families with young children for many reasons. Family mealtimes provide opportunities for children's nutritional intake, and they establish the eating habits children are likely to have for life. Studies have shown children start to develop their appetite and food preferences starting at the age of two [23], making family meals a key time for developing long-term food-related attitudes and behaviors. This importance has led pediatricians, nutritionists, and scholars to design guidelines and general principles for parents to follow at meals with their young children.

However, meals with young children have also been identified as the source of stress for many parents. Food neophobia and pickiness are common among young children [23], and research has indicated that parents experience stress as a result of children's meal-related tantrums, food pickiness, long eating times, and their need to exercise their autonomy [13]. Although tensions can arise in this context, parents also view meals as an important and valuable part of their children's daily experiences. They want meals to be a time when children learn table manners and practice engaging in conversations [30]. They value mealtimes as opportunities for family bonding and togetherness, and they regard the dinner table as one of the most important settings for this [41].

To relieve parents' struggles at meals and to enhance the aspects that families find valuable, researchers and designers in UbiComp and Human-Computer Interaction (HCI) have designed many novel technologies to encourage children to make healthier choices or increase their food intake. For example, there are apps and games to reduce picky eating habits [25], help children distinguish healthy foods from unhealthy options [58], and foster awareness and self-reflection

about healthy eating [70]. Other research has investigated children's needs at mealtimes, expanding their sensory experience by encouraging them to play with their food [58]. Jesús Ibáñez created a game for children to keep playing with their food after they are done eating [21], and DinnerWare reacts to the properties of the food by supporting artful expression [7]. There are also systems that are designed to facilitate the collaborative engagement of all the family members at the table [10]. These studies mostly identify a singular mealtime goal, and they attempt to create a solution for it, sometimes overlooking other stresses.

While technology has been designed to address tensions at mealtimes, points of contention remain in the parent-child relationship. As cited above, parents report being stressed and impatient with their preschoolers at mealtimes. They regard mealtimes as important for children's health, and they hope it will also serve as a time for family members to connect with each other. However, young children have their own will, and they want to exercise autonomy at mealtimes. The goal of this dissertation is not only to help children accommodate their parents' aspirations, but to also create the opportunity for them to exercise their own intrinsic motivation to be playful and to support their creative exploration in the everyday life context of mealtime.

I choose to focus on preschoolers and their parents because research has shown that, by this age, they are cognitively ready and able to meaningfully engage with digital media. They can also engage interactively with technology during play with their parents [71]. At this age, children also become marketing targets for educational applications, a multi-billion-dollar industry that seeks to monetize youth attention [8].

1.1 RESEARCH QUESTIONS

This dissertation investigates the role technology can play in family relationships, specifically at mealtimes. It examines the current and potential ways that young children can use emerging technology as a form of play at mealtimes with their families. The overarching research question for this dissertation is: **How might technology support a holistic family life at mealtimes?** Specifically, the aim is to answer four interrelated research questions:

RQ1: How do children express and enact values around mealtimes, and what can technology do to support them?

RQ2: What are parents' general attitudes toward children's technology use at and around this daily activity? What technology do parents approve of, and what do they not approve of? In what ways do parents think technology can be helpful or unhelpful?

RQ3: How do specific technological features support both children and adults in addressing value tensions at their mealtimes?

RQ4: How does technology engage children and adults in creating meaningful experiences in mealtime contexts?

This dissertation reports on the findings of four different investigations on families' current mealtime practices and their attitudes toward technology (RQ1, RQ2). Toward that end, low-fidelity and high-fidelity prototypes were designed, in a consecutive manner, to investigate what interactions families might have around mealtime technologies (RQ3, RQ4).

First, foundational knowledge was obtained about the values parents and children have related to mealtimes to understand what it means for parents to have technology involved in one of their family routines. Two methods were used to answer RQ1 and RQ2: participant observation and a survey of a speculative design for parents to explore the current practices of children's mealtimes

with their caretakers both at preschool and at home. These investigations helped deepen the understanding of how young children behave at mealtimes, their distinct and shared values, the adults' attitudes toward technology in this space, and the situated context of how technology might be designed in this area.

Then, a series of design artifacts for children are presented that correspond to what was learned from the previous studies. The design processes of the prototypes and the empirical results with the children and their caretakers are described. These investigations aimed to answer RQ3 and RQ4 on how designers can design technology that addresses value tensions and supports meaning-making through everyday family routines. Table 1.1 shows how each of the studies addressed the research questions.

Table 1.1. Overview of how the four investigations addressed the research questions.

	Understanding current practices at shared mealtimes	Speculative Design Survey	Lab study with 3 preliminary prototypes	A field study with Stamp Plate Prototype
RQ1: How do children and express and enact values, and what can technology do to support them?	X		X	X
RQ2: What are parents' general attitudes toward children's technology use at and around this daily activity?	X	X		
RQ3: How do specific technological features support both children and adults to address value tensions at their mealtime?			X	X
RQ4: How does technology engage children and adults to create meaningful experiences in mealtime contexts?			X	X

1.2 CONTRIBUTIONS

This dissertation makes empirical and theoretical contributions to the field, and introduces a new artifact.

The first contribution of this work is empirical. It documents how children ranging in age from 2 to 6 eat at preschools and how they eat at home. It also gathered data about how parents thought about speculative technology ideas for their children at mealtimes. Together with additional lab studies and field studies, the dissertation contributes to the empirical and generative understanding of parents' and young children's values during their shared mealtimes that considers family arrangements as well as children's developmental needs.

The second contribution of this dissertation is an artifact. A smart object, called a stamp plate, was created for children to use at mealtimes. It explores the possibilities of what technology can bring to parent-child shared mealtimes. Wobbrock and Kientz note that an artifact contribution can “reveal new possibilities, enable new explorations, facilitate new insights, or compel us to consider new possible futures” [128]. The stamp plate challenges the current widespread assumption that using technology at mealtimes is a bad parenting practice; and it facilitates the ability to investigate how the design may or may not be helpful to both parents and children for their mealtimes together. The dissertation contributes to the HCI community by providing a thorough and concrete research investigation into how to design smart objects for young children to use at home.

The third contribution is theoretical. This dissertation provides insight into what designers may do when designing everyday technology for young children. By introducing value tension as a framework to consider both parents and children's perspectives when designing for young children, this dissertation offers new ways to think about technology in young children's lives, such as

giving children autonomy in their lives and considering the people and artefacts around them in a holistic convergence.

1.3 DISSERTATION OVERVIEW

Chapter 2: Background and Literature Review

Chapter 2 describes the existing literature relevant to studies investigating the interaction of children, families, and mealtimes. This section addresses why mealtimes are important to children, and it identifies the role adults play in this domain. It also reports on prior work that has designed technology for young children's mealtimes and for family mealtimes. Previous work that looks at children's intrinsic motivation, such as playfulness and autonomy, were included in this literature review. The current frameworks for designing technology for heterogenous groups were also addressed.

Chapter 3: Understanding Children's Mealtime Practice

The first study aims to understand what children and parents' value when they dine together. Because of their developmental stage, asking preschoolers directly about what they want or what they think might not be the most fruitful way to design for them. Thus, this chapter describes the field observations of children's lunch and snack times at two preschools. In this study, the children's caretakers (teachers and parents) were interviewed to learn about what they care about when they have mealtimes with children. To answer RQ1, this part of the study provides details about the ways in which value tensions between parents and children are expressed, and how parents' goals for mealtimes are enacted.

Chapter 4: Understanding Parents' Perspectives on Mealtime Technology

The second study is a speculative design survey to help understand what parents' preferences and considerations are when they are presented with different forms of technology for different purposes. This investigation is specifically adult-facing because parents exercise the power privilege in parent-child relationships [1]. They also hold the main decision-making power in deciding which digital devices enter the household. This investigation helped answer RQ2 about what type of technology is acceptable for parents to give their children during their shared mealtimes.

This study provides a generative understanding of how parents might respond to novel design solutions for mealtimes, and how their attitudes might extend to other aspects of family life, because concerns about personification and surveillance, acceptance of the familiar, and tension related to the idea of outsourcing parenting responsibilities to a machine, among other themes, all have the potential to transfer to other contexts.

Chapter 5: Designing and Evaluating Mealtime Technology for Young Children

Using what was learned from the studies presented in Chapter 3 and Chapter 4, three value tensions at young children's mealtime were identified. Based on the value tensions, three preliminary prototypes were designed for children to use at mealtimes; each prototype was designed to correspond to a specific value tension. This chapter describes the laboratory study result of children using the prototypes and what adults thought of the prototypes. It also describes what technology features work and do not work, to answer RQ3 and RQ4.

Chapter 6: Stamp Plate: Technology for Family Mealtime with Young Children

Building on the formative results described in Chapter 5, I worked with a team of designers and developers to build the stamp plate into a more complete digital prototype. Toward that end,

a field study was conducted with 14 households, and parents and their children were given stamp plates to use at their mealtimes. It was found that the stamp plate not only increased the preschooler's food intake, it also prompted parents and children to create meaningful experiences, such as simple math learning and playful interactions. This work describes the types of meaningful experiences that emerged from interacting with technology, in response to RQ4.

Chapter 2. BACKGROUND AND RELATED WORK

For young children, family meals are an enjoyable and developmentally useful part of daily life. Although prior work has shown that technology solutions can enhance children's eating habits and mealtime experiences in valuable ways, other work demonstrates that many families are hesitant to use technology in this context.

In this chapter, I describe the ways in which existing work has approached the design of technology within the intersection of food, mealtime and families. A large body of research has considered young children's use of mealtime technology with respect to adult's point of views, such as those of psychiatrists and parents. This perspective is intertwined with the issue seen by many adults regarding how much technology exposure children should have. Other body of works look at children's playfulness and autonomy as an intrinsic motivation to interact with the world and technology around them. With this in mind, I describe theories and frameworks that help to frame this design space.

2.1 YOUNG CHILDREN'S MEALTIME

Mealtime is essential for a child's nutrition and is an important part of a child's day [20]. Mealtimes provide children with the opportunity to learn about nutrition, which will expose them to diverse food categories and set up healthy habits for the rest of their lives[20]. Mealtime also provides children with the context to learn about social norms and table manners from their caregivers in preschools and at home [42,73,90]. Children learn about food sharing, routines, rules, manners and build a sense of community both in families and in classrooms [90]. Moreover, meals provide a context for enjoyment. Families bond through engaging together during meals at home, and children socialize with their classmates during mealtimes at school [43,90].

However, engaging in mealtime is a complex practice with the potential for both positive and negative experiences that require work and intentionality on the part of adults and children. Prior work has shown that for many families, eating with young children comes with challenges for all parties, resulting in negative consequences [20]. For instance, parents who are anxious about attachment were more likely to use controlling-persuasive tactics to coerce children to eat, which can lead to poor self-regulation and to emotional eating [98]. Steinbekk *et al.* show a 4-year-old who is a picky eater is highly likely to remain so [118]. These authors suggest children be given some autonomy with their food preferences. These studies together suggest that children and adults each hold distinctive values at mealtimes, and addressing both values together, rather than one, is in need of further investigation.

Food neophobia and picky/fuzzy eating are the most concerned eating disorder at preschooler's age. According to Dovey *et al.*, the two factors are different but often used interchangeably [23]. They define food neophobia is the reluctance to try new food, and picky/fuzzy eating is defined as children who consume inadequate amount food[23]. They summarized that food neophobia is the first time when children refuse to try a new food item, and the consecutive times when they refuse to eat it is what constitute picky eating. Pressure to eat, personality factors, parental practices/styles and social influences may all be the causes of picky eating behavior. Research has detailed the way in which parents' attitudes toward food shape their children's attitudes toward food[112], and the food parents provide their children plays a significant role in children's health [118]. In addition to preparing meals, parents also tend to play a primary role in the development of their children's table manners and socializing skills such as conducting "appropriate" conversation at mealtimes. Family mealtimes are cultural sites for the socialization of children to become competent and appropriate members of society[90].

2.1.1 *Strategies for Eating Intervention*

Researchers have been finding ways to deal with preschooler's neophobia and eating pickiness, and they are mostly done in school settings. Recent studies mainly focus on vegetable and fruit intake since these items are the food categories identified as most commonly rejected by young children [20,57,93]. Other work has found it takes 15 to 20 bites of a food for a child to reverse the neophobia. One of the proven effective ways is to give children visual cues [93]. Rioux gave 70 children from ages 3-6 visual exposure cues where clear placemats with pictures of vegetables were introduced for two weeks at their school cafeteria and found children's overall vegetable intake increased both in vegetables that were represented on the mat, as well as those not presented [107]. This study is in line with a body of research that indicates mere visual exposure to vegetables and fruits has the positive effect of increasing their overall intake at home and school [107]. Along the same lines with food exposure, a study gives children rewards for eating vegetables and fruits. The reward system is children who eat 1-3 bites get a sticker, eat 4-7 bite gets a sticky wearable badge, and eat all 8 bites get a construction toy set. Children only receive the rewards during lunch time, but are given the same set of food for lunch on alternative days. This study finds children increase their food intake even during lunches when they are not rewarded, and food intake increases even with food items that are not included in the reward system, and that positive effects remains 6 months after the reward period that only continued for 16 days [71]. These studies show visual cues and giving out direct rewards to preschoolers for their eating behavior helps relieve their food rejection and increased their overall food intake.

2.1.2 *Mealtime Interventions in Preschools*

A number of studies have examined meals and meal-related interventions in preschool with regard to their nutritional value. Prior research has found that food-insecure children have trouble performing well in school [126], suggesting that it is important to ensure that children are well-fed in the classroom. Other research has examined the social characteristics of classroom meals, for example, demonstrating that meals provide children and teachers with the opportunity to engage in extended conversations [17], and that the quality and quantity of teacher-child interactions are greater during meals than during other semi-structured classroom activities [7].

Several studies have examined the design of the classroom environment for its impact on meals. For example, Snack Talk cards—pictorial flash cards with child-preferred topics—have been shown to increase social conversation during meals in inclusive preschool classrooms [47]. Other work has shown that the design of mealtime structure can influence children’s behaviors and interactions. For example, serving food family style can increase the incidence of preschoolers’ meaningful participation in social aspects of the meal [46].

Other work has examined the design of digital technology for activities in preschool classrooms that are unrelated to meals or eating. A number of apps have been designed to teach preschool math concepts in classrooms [131]. Westlund and colleagues found that robots in the classroom can increase inclusion and provide opportunities for social learning that teachers are excited about [67], and in a long-term classroom deployment in preschools, Sylla demonstrated the Touch-Organize-Create system can scaffold the development of literacy skills [120].

Together, this body of work suggests that: 1) meals are an important part of the preschool experience, 2) the design of mealtime structures, activities, and tools can shape children’s and teachers’ experiences during the meal and the value they derive from it, and 3) thoughtfully

designed digital experiences can play a positive role in classrooms. Here, we combine these related strands of research to explore design opportunities for classroom meals.

2.2 DESIGNING FOR HUMAN FOOD INTERACTION

A number of prior studies have explored the design of technologies for children's meals. This work has focused on designing tools to facilitate healthy habits, such as apps and games to reduce picky eating habits [45], help children distinguish healthy foods from unhealthy ones [79], or foster awareness and self-reflection about healthy eating [100]. Other work has leveraged user-centered design practices to create smart objects for meals that support children with developmental disabilities who struggle to use traditional utensils [44]. These studies and others demonstrate that technology can play an effective and useful role in children's mealtimes and everyday life. However, rather than just designing adult values into technology for children, I aim to explore design that meets both parents' and children's values at mealtimes.

Many HCI research systems have been designed to enhance human-food interaction. This work includes projects seeking to enhance the taste of food as it is consumed [88] provide entertainment during meals [88], deliver memorable experiences around food [33], and help people eat healthily [96,101,113]. These diverse investigations leverage augmented reality, screens, smart objects, and other digital tools to enhance or shape users' experiences with food [14].

Most studies exploring this space focus on a problematic aspects of users' relationship with food and attempt to provide correctives [48]. Bell and Kay argue that researchers see the kitchen as simply another site where digital artifacts might be introduced, and warn against designing technology for meals without understanding the surrounding meaning-making processes [2]. They point out that many approaches to the design of kitchen technology have focused on health and efficiency and ignored other eating related values, such as the ways in which food is tied to national

and regional identity. They argue against limiting technology design for meals to improving efficiency and advocate for examining other social and cultural aspects of food when designing the kitchens of the future.

In response, recent HCI studies have sought to understand human values, family routines and interactions among family members around the dinner table [73,87,125]. Most notably, Grime and Harper [48] argue for studying the celebratory aspects of people's interactions with food, suggesting that such insights can lead to designing types of technology that are more contextual and reinforce positive human-food relationships. Other studies use qualitative methods, such as observing family dinner times and semi-structured interviews, to examine what role personal technology plays in this context [19,31,32,34]. Ferdous and colleagues designed an application called "TableTalk," which integrates personal devices of people who share a mealtime into a single shared display [33] to make personal content part of a collaborative experience.

2.3 DESIGNING FOR CHILDREN, FAMILY, AND MEALS

A large body of literature in HCI explores the design of technologies for families and children. This often focuses on family communication, coordination, togetherness, and play [41,62,75,103], particularly connecting with distant family members and communicating within the immediate family [65]. A review of the field of interaction design and children found that the majority of work in this space focuses on families with children between the ages of six and twelve years old [60], leaving notable gaps in my understanding of both older and younger children's experiences with technology. Other work explores the technologies children design for themselves, using participatory design practices to engage children as partners in creating digital experiences aligned with their own needs and values [26].

A smaller body of work examines the design of technology for children and families specifically in the mealtime context. Many of these research prototypes are ubiquitous technologies, such as a smart tray to persuade children to focus on and consume food during meals [68], a smart flatware set that attempts to persuade children to increase their vegetable intake [61], or a pressure-sensing fork and cup to persuade children to eat a balanced diet [64]. Similarly Zuckerman and colleagues developed Dataspoon, a digitally enhanced spoon to help caregivers of children with motor disorders like cerebral palsy collect data about children's motor movements [132]. Randall and colleagues designed a plate and water bottle with embedded sensors to encourage two- to five-year-old children in low-income families to adopt healthy eating habits [104].

These studies and others suggest an interest in developing novel technologies for family meals that encourage children to engage in food-related behavior change. My work promises to inform the design of such systems by providing insights into families' interest in adopting technology at meals, particularly novel technologies in newer formats. Although my investigation does not probe children's values and perspectives in this context, it will sensitize designers to the needs of parents and the likelihood of these systems appealing to this user group.

2.3.1 *Parents' Attitude About Children's Technology Use at Meals*

However, despite these suggestions that technology can provide useful mealtime support, many families report tension around the idea of mealtime technology use, and experts recommend minimizing or eliminating certain forms of technology use in this context, potentially leading to broad pushback against technology at the table. Currently, the American Academy of Pediatrics (AAP) recommends parents of young children create technology-free zones in their homes, calling out family meals as a particularly useful time to disconnect [135].

A growing body of work in HCI has explored parents' attitudes about such practices, probing the ways in which parents alternatively embrace and resist their family's use of technology, looking both at families' attitudes toward technology generally and their attitudes toward technology during meals in particular. For example, Hiniker and colleagues show that parents define context-specific boundaries on family technology use, and children and parents alike feel that family members of all ages should set technology aside at times when it infringes on interpersonal engagement with physically co-present family members [55]. Moser and colleagues document that adults often feel technology at meals is inappropriate and that these feelings are augmented when children are present [87]. However, this resistance to technology use at meals is not uniform or deterministic. Lanette and Mazmanian show that parents situationally enact technology rules in domestic settings according to their ideals, resources, emotions, immediate needs, and intuitions[82].

Together these studies show decisions around children's technology usage are often fraught for parents. Although families are eager adopters of technology [9], regularly rely on technology to support or resolve domestic challenges [60], and face common struggles around meals [122], families differ in how open they are to digital technology as a tool for addressing meal-time struggles or enhancing meal-time experiences. As new end-user-facing technologies are invented, designers have more options for supporting families via innovations they find acceptable. Here, I examine parents' reactions to integrating technology supports into meal-time experiences, looking across a diverse set of technology types.

2.3.2 *Informal learning and Joint Media Engagement*

Informal learning refers to learning outside of the classrooms and in an unstructured environment, as opposed to formal learning that is majorly classroom-based and institutionally

structured[80]. Most importantly, learners primarily control what and how much they are learning in informal learning settings[80]. It can happen in homes, museums or organizations and etc. Large scale studies have found out that children who start school with poor literacy and numeracy skills perform relatively behind in school as well[74]. Research have identified collaborative learning between parents and children has positive outcomes for children's learning and family interaction[5].

For example, research identifies children who received numeracy education at home in preschool ages have better math performance in elementary schools than those who do not[3], and parents are children's major source of informal learning educator outside school[74].

In learning how to code, parents and children engaging in learning computing skills together predicts the children's interests in computing[8], and their creativity and learning skills improve. This shows that children learn better when they have parental support.

Collaborative engagement with technology, also called joint media engagement[121], is important when designing for children and learning. According to Takeuchi & Stevens, children create meaningful connections among representations, interests, and experiences by jointly engaging in digital media with others. Takeuchi & Stevens identify six conditions that lead to productive JME, including "mutual engagement", "dialogic inquiry", "co-creation", "boundary crossing", "intention to develop", and "focus on content, not control"[121]. The authors call for better understandings of how people use media together and how we design technology for collaborative media engagement. The learning benefits of JME serves as a theoretical ground for the designing and analyzing of this work.

2.4 PLAYFUL DESIGN FOR CHILDREN AND FOOD

Play is a fundamental activity for every child. They learn crucial skills including how to communicate, develop other social and emotional skills, self-regulation and diverse perspective of their lives [116]. And play is often not a set of predetermined activities, but emerges naturally in different everyday settings. Sicart[116] believes that we see the world through playfulness, and we can structure the world as play. Playfulness is often not seen as an activity, but an attitude that co-exists with a situated real-life activity. While Papert's notion of "constructivism" is a theory about how learners use what they already know and the environment around them to construct mental models and understand the world around them, he thinks when children play, it is when they build powerful ideas and make their own knowledge[95]. Resnick extends this idea and points out that when children play, they engage in a variety of possibilities to explore, experiment and collaborate, coming up with creative game play which is essential for them to make their own knowledge[106].

And HCI and Ubicomp have been exploring ways of engaging eating experience with playfulness. Eating is an essential part of our daily lives and it often happens more than one time in a day. As such, HCI community has started to design playful eating experiences to enhance social and cultural entertainment[124], memory, reflection, and affection[66] [110]. Other studies investigate ways to support children's sensory experience through play and games [88]. However, these studies, especially the systems created for children, are designed as restricted games with fixed functions, instead of building on the preexisting activities or routines that children have already doing, or give them opportunities to explore creative ways of engagement.

2.5 VALUE TENSIONS AND CHILDREN'S AUTONOMY

Value tensions refer to instances in which two important values are in conflict in a given situation [40]. A number of studies have examined such conflicts as a part of the design process. Yassaee and Winter identified a number of value tensions in the design of health-surveillance technologies for the workplace, such as the conflict between privacy and well-being and the conflict between work and leisure [130]. Miller and colleagues examined conflicts related to privacy and reputation in a groupware system and demonstrated that value-sensitive design practices can successfully address these tensions [85].

Many prior studies have shown that examining value tensions can be a productive framing for contexts that involve children and the adults who support them. Existing research has identified tensions between academic success and personal fulfillment [128], children's autonomy and online risk [18], the need for play and the need for safety [84], among others. Given that the purpose of this project was to better understand and design for children's values while continuing to support the values of teachers, I built on this prior work by examining value tensions in the context of preschool meals.

2.5.1 *Respecting the Expertise and Autonomy of Children*

Research in child-computer interaction increasingly emphasizes children's agency and the importance of respecting the inherent dignity and self-ownership of every child. Prior work advocates for incorporating children in the design process [25] and recognizes that children are experts on childhood with insights that cannot be accessed by probing adults' perspectives alone [24]. Research into the design of novel technologies for children also increasingly treats children's values as core design principles [54], [36] [69]. As a result, a number of methodological

innovations seek to draw out children's perspectives and access their design insights (e.g., [28,30,49]). In what follows, I extend this orientation to the design of technologies for children's meals. By using the value tension lens [86], I am able to highlight not only children's perspectives, but also the interplay between children's and adults' values and the ways in which they might come into conflict.

Chapter 3. UNDERSTANDING YOUNG CHILDREN'S MEALTIME PRACTICE

To design technology for children's mealtime, I begin with understanding what current mealtime practices young children are engaging in with their caregivers and the arrangements around them. I conducted field studies both in children's preschools and in their homes on how they eat and relate to the food, as well as how they know about and engage in mealtime practices.

3.1 METHOD

As the goal of this work was to understand what current mealtime practice children are engaging in with adults, I conducted field studies both in children's preschools and in homes. The investigation is consisted of participant observation and interviews. First, I conducted participant observation in two preschools and interviewed the teachers in two schools about what their values are at children's mealtimes. Second, I performed a qualitative study using in-home observations and interviews to closely examine parents' needs and goals during family meals. I will detail the findings and what I learned about contemporary young children mealtime is like.

3.1.1 *Preschools Observations*

First, I conducted eight interviews with preschool teachers from two different preschools about their values at mealtimes and the routines they perform. I also observed 23 meals (including lunch, morning and afternoon snacks) at those two preschools with classes of about 10-20 students. Either one or two researchers went to each meal and conducted ethnographic observations by jotting notes about children's and teachers' motions, interactions, emotions, styles of eating, and speech on paper or a laptop, and later transcribing these into field notes. The two schools represented two

different philosophies and social demographics; the first is a university Montessori preschool and the second is part of a federally funded program to increase low-income children's school-readiness. The first school also served lunch communally (with all classrooms eating together) while the second school served lunch within individual classrooms. Despite these differences, I observed the same value tensions develop within the two schools. I did not collect demographic data on individual children.

3.1.2 *Home Observation*

I visited eight homes of families with at least one child between the ages of two and six and observed one dinner with each family (see Table 3.1). Following dinner, I conducted an interview with one parent, asking about family practices and posing follow-up questions related to the meal I observed.

Participants were recruited through family housing email lists and neighborhood parent groups in the greater metropolitan area surrounding my institution. I asked parents who responded to my solicitation to schedule a date for one or more members of the research team to visit their home to observe a meal the family would eat together. All observations included the entire nuclear family (either one or two parents and one or more children), with no friends or extended family members present.

At the conclusion of the meal, one researcher conducted a follow-up interview with a parent. I chose to interview only one parent to minimize disruption and allow the second parent, if present, to attend to the children. Here, I probed parents' attitudes toward family meals and the aspects of meals they enjoy and find challenging. Sample questions included: "*What expectations do you have for your children at mealtimes?*" "*What are your children's favorite and least favorite foods?*"

and “*What do you value the most at mealtime with your children?*” Most interviews lasted between 29 and 52 minutes, and most observations were between 23 min and 53 minutes.

I both videotaped these meals and generated detailed field notes about the meal based on real-time jottings or reviewing video footage. All interviews were audio recorded and transcribed. Using a grounded theory approach [10], I analyzed observations and interviews collectively and identified a set of open codes related to common themes in parents’ behaviors, values, and goals. The first and second author developed the code schemes and coded the transcripts together in qualitative coding software “dedoose”[133]. Later, I went through iterative rounds of coding and wrote memos to discuss in the research group. I then collaboratively converged on four common themes that reflect parents’ most salient concerns in this context.

Table 3.1. Participants in the qualitative study

	Family members at dinner	Interviewees
P1	Mother, father, girl (5.5yr), boy (3.5yr)	Mother
P2	Mother, boy (5.5yr), boy (2.5yr)	Mother
P3	Mother, father, girl (3.5yr), boy (1.5yr)	Mother
P4	Mother, father, boy (2.5yr)	Mother
P5	Mother, father, boy (3.5yr)	Mother
P6	Mother, father, girl (4.5yr), girl (2.5yr)	Mother
P7	Mother, father, girl (7yr), girl (5yr)	Father
P8	Mother, father, girl (3.5yr), boy 1.5yr)	Mother

3.2 FINDINGS

In this section, I describe and analyze findings from the preschool observations and home visits separately. It is worth noting that at school, children are less monitored by adults and I observed more creative and playful eating behavior than in home visits. At homes, children are closely monitored by their parents of their eating behavior. My presence there as an observer may strengthen the degree of behavior control. Because children's spontaneous behavior is more obvious at preschools, I use value tension [86] framework to account for both children and teachers' value at the mealtimes. For home observation, I summarize four goals that parents care about at the mealtimes with their young children.

3.2.1 *Value Tensions*

Value Tension 1: Sitting Still vs. Comfort

In the classroom, I observed teachers working to maintain order by restricting children's ability to wiggle and move about, and many children continuing to wiggle nonetheless. Rather than sit in their chair for sustained periods, children seemed more comfortable letting their bodies fidget, twist, and turn. They regularly stretched their arms, bounced in their chairs, stood up aimlessly, and walked around the room during the meal. Although children did not show evidence of willful rebelliousness (expressing disobedience for its own sake), their inclination to move about the room appeared to conflict with teachers' desires. I observed that when a teacher was supervising a classroom of preschoolers, roaming children created stress for the teacher, and teachers were constantly reminding those students to sit in their seats.

Teachers repeatedly referred to kids standing up as "*movement*" and "*chaos*" and they spoke of these terms in contrast to their hope for children to sit still themselves. During interviews,

several teachers indicated that the classroom lunch felt tense and demanding. Some mentioned that they sometimes needed to step out for five minutes when things “*heated up*” at lunch. The pause provided time to de-stress and return to the classroom with more patience than when they left. They valued keeping the children seated in order to create a more relaxed environment. In interviews, preschool teachers talked about their desire to have kids sit still. Teacher P11 described children, “*getting up and down a lot, wanting to get out of their chairs, and go get more food, stuff, or just run around*” as a primary “*difficulty*” at mealtime, suggesting that it is one of the biggest stressors for her at mealtime.

In one school, teachers talked about strategically rearranging children’s lunch set up in order to prevent them from needlessly standing up and walking around the room. Previously, the teachers had served lunch cafeteria style, such that children would serve themselves at a counter and then sit down. But the teachers had recently switched to a family-style meal, with food served at the table to be passed and shared, mainly to minimize children walking around without permission. With the new arrangement, teacher P9 told us they were able to “*cut back on the movement and chaos,*” suggesting that this movement had a notable impact on teachers’ experience at lunchtime.

“Before, the food was all on a counter. I wanted them to raise their hand and ask. Sometimes they would, sometimes they wouldn’t. The fact that they don’t have to get up and walk across the room, it just cuts back on the movement and the chaos. Now, they’re sitting at their table, and they don’t have to get up.” (teacher, P9)

However, I observed that even with the new arrangement, the kids still wanted to bounce, stand up, turn around, or just wiggle on their seats. They seemed to move without intending to explicitly disobey or undermine their teachers, but rather as part of the natural rhythm of their routine. At a couple points, I observed children beginning to walk across the room, and then pause and return

to their seat, as though they suddenly remembered they should not have done this. When teachers asked children to sit down, the children would never verbally oppose, though they would sometimes not seem to hear the teacher or process the teacher's remarks.

Around the mealtime table I observed two main types of movement: walking around the room and wiggling or standing at a seat. When children left their seat it often seemed to impact whether they ate, but when they wiggled or stood near their seat, they typically continued eating.

The boy is active and restless (he was singing and talking earlier). He's sitting on his knees, shaking the chair as he faces the carpet (where kids from other tables have started to congregate). His shaking moves the chair toward the carpet, and once he's gone a foot or so, he gets off and puts the chair back, facing the table again. He eats his bread, but uses his free hand to pull the chair onto its front legs.

Although the teachers expressed discomfort with a lot of motion, they seemed to accept children moving in their seats while eating. T2 was acutely aware of this tension in her interview, bridging this tension a bit with her understanding of the children's positions. She described how the children's movement was unconscious and how it was difficult for children to sit still. For this reason, she explained, she found it difficult to manage children who moved because moving feels good. Her understanding suggests that teachers may have the capacity to accommodate wiggling and motion, provided that they still feel that the room is under control and not "chaotic."

Value Tension 2: Using Utensils vs. Autonomy

Teachers viewed it as their responsibility to teach children basic life skills, including how to use shared and personal utensils. They explained wanting to do so both to keep the classroom clean and sanitary, and because they wanted kids to learn an important life skill. Teachers' reminders for children to use their utensils occurred repeatedly throughout the meal. The children sometimes

responded positively to this prompt, but other times they ignored it. They seemed to prefer eating their meal independently over being asked to adjust how they ate.

The skill of using utensils to pick up food was visibly important to the teachers—an ability the teachers wanted the children either to practice or develop quickly. When teacher P9 noticed that a child was not using a fork, she pointed it out to teacher P11 who was supervising that child, and P11 began to help the child use his fork. Justifying this type of prompt, teacher P15 explained that the children need basic motor skills—like the ability to use a fork and spoon and pour milk into a cup—to feed themselves when they go on to elementary school. Teachers felt it was their responsibility to help children cultivate this skill.

Despite discouragement from teachers, the children readily and repeatedly ate comfortably with their hands. When they found the opportunity to do so, they appeared cheerful, comfortable, and ate quite a bit.

A girl is eating the meatball using her hands after finishing her pasta with her hands as well. Most of the kids are eating the pasta with their hands. There are two girls sitting at different tables doing the same thing: eating with their right hand and touching the meatball pasta bowl with their left hand.

Although focused on their hands, children did not appear to actively rebel against using utensils. Many were able to avoid utensils but would still try them. Although children often did not appear fully comfortable using utensils, they showed interest in learning. At times, children tried to use their utensils in peculiar ways. For example, they would use their hands to put a blueberry or a piece of chicken on their utensil, and then bring the utensil to their mouth. In another instance, a little boy used a spoon in his right hand to eat cottage cheese, then moved the spoon to his left hand so he could pick up pieces of fruit with his right hand. Then, once he ate all the larger pieces

of fruit, he used his right hand to push the fruit onto the spoon, which was now in his left hand. This dance-like process between utensils and children's hands suggests that picking up food with a utensil was still a bit difficult for these preschool-aged children. However, it simultaneously demonstrates some interest in using these tools.

Although children did not appear to be staunchly against learning to use utensils, the teachers' constant reminders did not appear to effectively encourage this skill. The children did not seem to want to be continually interrupted and corrected by verbal reminders from teachers. For example, I saw numerous instances where a teacher would remind a child to use a fork, and the child would simply ignore what the teacher was saying.

Although teachers wanted children to use their utensils to eat their food, they had few strategies for encouraging this behavior. Directing the children to use utensils did not appear to be the most effective strategy, since children often ignored these reminders, despite their willingness to practice using their utensils on their own.

Value Tension 3: Cleanliness vs. Creativity

Throughout my observations, I saw that children loved building and playing with anything on hand, including food. The adults I observed aimed to foster a tidy and hygienic eating space around children, which meant treating food as something to consume rather than something with which to explore and play. Thus, I continually observed competition between teachers' need for cleanliness and children's need for creative and playful expression.

Children's interest in food as a playful object was evident in many instances. For example, one child pretended the top of her banana was a straw, and placed it in her cup, pretending to suck it. Another child crumbled crackers and used the stickiness of his banana to lift up crumbs and take

bites of the two together. Other children blew bubbles in their drinks and aligned foods in artistic arrangements on their plates and spoons before they ate.

In addition to the food itself, the spoons, forks, and bowls were a part of this playful activity. Consider the below episode where a preschooler flips the script between utensil and food:

One child's mother asked him to sit down. He sat down and used the fork to crumble one of the crackers. A teacher came and said hello. Before eating anything, he then picked up the banana and tried to peel the skin off. Half way through his mother helped him to peel it off and he took a bite. Then he picked up a piece of cracker and ate it. His mother asked him what he was going to do with the crumbled cracker. He did not say a word but picked up a banana and dipped it into the cracker crumbs like a stamp and then took a bite. He used the fork to further crumble the other crackers, while his mother was describing what he was doing. He picked up the banana and dipped it into the crumbs again and then ate the big chunk of banana.

Mess did not have the effect on children that it seemed to have on the adults. Whereas the adults often expressed feeling uneasy around mess, children did not tend toward feeling upset or uncomfortable when the table became messy. Sometimes they reacted with intrigue or fascination. Other times I observed children spill liquids and drop foods without exhibiting any reaction to it at all.

Although children approached food as a creative medium, the teachers I observed did not see this as a practical or appropriate way of engaging with food at mealtime. Teacher P13 described this divide, explaining that when a child has a sensory need, the teachers do their best to support that interest during playtime, so the child is not as tempted to apply his sensory need to the food by playing with the food.

Additionally, teachers were concerned about staying on schedule and saw children's food play as an impediment to this. In the classroom, teachers expected children to focus on their food, so that they would eat enough in the short amount of time allotted for the meal. Teacher P14 told us her students have 30 minutes for lunch, which included washing their hands, getting to the table, eating the meal, and cleaning everything up. There was really only 15-20 minutes for eating, she explained. The structure of mealtime at these schools did not create much time for open, unrestricted play.

3.2.2 *Mealtime Goals*

Although each family presented unique interests, goals, and interpersonal tensions at meals, I encountered four dominant themes that spanned participants. These four concerns arose from parents' goals for children during the meal and were reflected in a variety of behaviors as well as their interview responses. Each of these four parent-centered goals (promoting healthy eating habits, encouraging children to eat more food, encouraging children to engage in conversation during the meal, and teaching normative table manners) are described in more detail below.

Healthy Eating Habits

Parents said that they try to promote food exploration and increase children's likelihood of eating a mixture of diverse, nutritious foods. Parents reported that this work requires significant time and labor, including preparing food, keeping track of a variety of details around food consumption over time, and designing their mealtime environment to promote eating habits they consider desirable. For example, P7 spoke at length about his definition of healthy eating, the activities he engages in to promote healthy eating in his children, and his motivations for doing so: *"I think about it in sugars, carbs, fats, and proteins. So I make sure for their after school snack they get a dairy because dairy has the fat and the protein and it helps them recover from their hard*

day. Then they generally get like a cheese stick or they get a yogurt thing. Then I always have fruit, like they love apples. They love them. I try to fill them with veggies, but their nanny doesn't sometimes give them to them. If they don't eat the food then they are just hungry. They suffer because their attitude and their mood is affected.” (P7)

In this snippet, P7 touches on many aspects of the labor and planning he engages in to promote the eating behaviors that he feels are most likely to maximize his children’s well-being. Many parents reported thinking ahead and keeping track of their child’s preferences and likelihood of eating healthy foods. Several parents reported that they memorize what their child eats at each meal, and they plan in advance to provide a mix of food over a time horizon of several days or more. For example, one mother said that if she saw her child only had a few bites of beef at dinner one day, she would make chicken (her child’s favorite protein) the next.

In addition to carrying this mental load and planning for healthy meals in advance, parents also explained that they encourage their children to eat a diverse mix of foods during the meal itself, a practice I observed first-hand. Several parents stated in the interview that they use a “one bite principle” at dinner table, such that children are expected to try at least one bite of the food provided to them. As P4 explained, *“If they don’t like it, they don’t have to eat it. But they have to try one bite. Just one bite.”* In observing another family (P8) who also adopts this principle, I saw a girl picked up a food and described it as “yucky.” Her mother replied that it was not yucky and asked her to try it. The child did so and did not continue eating it. Several minutes later, the mother asked the girl if she did not like the food and asked her to eat more. The girl ate a tiny bit and then stopped. Parents used a variety of similar techniques to encourage their child’s consumption of particular foods, such as squeezing in particular food items, like adding two eggs to a pancake recipe that calls for one to increase a child’s protein intake (P3).

Eating More Food

Conversations about what children eat and how much they eat dominated mealtime interactions during my observations. Throughout the meal, parents used a variety of tactics to encourage their children to eat what was on their plates. This included verbal reminders, modeling, and pretend competition.

Parents' use of verbal reminders to encourage children to focus on their food and to consume more was nearly universal. This sometimes took the form of a simple reminder like, "eat your food," and at other times involved discussing nutrition and reminding children about nutritional properties of their food. For example, P1 asked her three-year-old son, "*Do you like veggies and meats? It looks like you're not having them. There're a lot of protein in meat.*" When P7 was in the middle of an engaging family discussion, her mother nudged her to redirect her attention back to her food by saying, "your fish," and giving her daughter a firm look. In response, the child immediately turned her attention to the fish on her plate.

Parents frequently praised elder siblings or parents eating a particular food as a means of encouraging a younger child to eat the same item. P1 constantly reminded her son of the fact that his older sister was eating on her own, finishing her food quickly, and focusing quietly on her food while eating. In other cases, I saw parents engage in manufactured competition with children, saying things like, "*I finished my pork and now I'm going to eat yours*" (P7) several times as a father pretended to reach out and eat the child's food. Each time the father said this, the child took a bite. Another father (P2) brought a small pig figurine to the table where his daughter remained as the only member of the family still finishing dinner. He held the pig near his daughter's plate and used a cartoonish voice to say: "*I am a hungry piggy and I am going to eat your salad!*" The girl giggled happily and continued eating until her father felt she had eaten enough and abandoned

the game. Across these and other instances, parents engaged in lightly manipulative tactics to encourage children to stay focused on their food and eat more than they otherwise might.

Table Manners

Across families, I also saw that children's behaviors and table manners were routinely a topic of discussion and often dominated mealtime interactions. Parents continually reminded children not to speak with food in their mouths, interrupted conversation to remind children to use utensils, and asked children to sit still at the table. These reminders came in different forms but were most often verbal; occasionally, I observed parents give children a stern look as a way of admonishing them for a lack of manners or for a behavior the parent felt was inappropriate.

Sitting at the table while eating presented the greatest challenge for children and was the most frequent source of tension between parents and children. Parents explained in interviews that they feel children need to focus on their food during meals and that sitting at the table is a communal act that is an important part of family life together. As P6 explained, "*they've never been allowed to eat separate from the table...I sit for a set amount of time and I have conversation.*" Despite the importance parents placed on this experience, children regularly moved about during meals and struggled to stay seated.

Parents asked children continually to sit back down as they moved about. For example, in P6's family, I observed at one point during the meal that the father got up to get the child a drink from the kitchen. The child reacted by immediately getting up from her chair as well. Her mother then asked the child to return to her chair and to drink her milk at the table. The child asked in reply if she could drink it on the couch, and her father told her no. Similarly, when P2 (a mother) was retrieving more food from the kitchen for her elder son, the younger child stood and wiggled in his

booster seat. She reminded the younger boy several times to sit on his chair, and simultaneously heaped food on the plate while keeping an eye on the wiggly child.

Mealtime Conversation

Finally, I observed that parents placed great importance on leveraging mealtime as an opportunity for conversation and bonding. They would routinely try to hold conversations with children about their day, pushing for conversation even when children were uncommunicative. Parents asked questions about topics they knew were relevant to their child's day, such as "What did you draw at in the art class today?" or "What did you do in the gym this afternoon?" Parents often followed up by trying to recap the child's stories or ask their child how they felt about specific events.

Although children were sometimes reticent, at other times, asking children questions about their day sparked a range of additional stories. For example, one child asked his mother if she was "very small (*hěn xiǎo*)" when she was a baby, a question that sparked a long conversation about each of the babies in their extended family. Other conversations began with parents trying to appease their child or fend off a possible meltdown. One girl expressed considerable concern that someone had licked her cup lid. After her father assured her he had cleaned it several times, they went on to talk about what kinds of items she cared to keep clean and which kinds of items she did not mind getting dirty. In most cases, these exchanges unfolded by parents prompting conversations and asking follow-up questions for their children to answer.

Sometimes such conversations surfaced opportunities for children to expand their vocabularies and practice language skills. I observed several moments of miscommunication, as parents did not always understand what children tried to tell them. Through continued conversation and iterative

back-and-forth, parents and children were able to build rapport and shared understanding of the child's communicative intent.

Parents also said explicitly during interviews that meals provide an important opportunity for togetherness. As P6 explained, *“What that [dinner conversation] means for us to connect as a family...to learn about each other's day, especially now that we're going to be going in different directions. And to begin to build a platform for just thinking ahead my kids being in elementary school, then middle school. When it becomes potentially harder to connect with their social emotional sides, that aged kid. We're sitting at a table together. I might be in all different directions all day long but this is...[the] time of day when at breakfast and at dinner. We're going to be together.”* P6 views meals and meal-time conversation as a chance to reconnect as a family and resist outside forces that might push them in different directions. Parents regularly described meals as an important site of conversation, bonding, and togetherness for their family.

3.3 DISCUSSIONS AND CONTRIBUTIONS

These observations and interviews provided me with a formative and generative empirical understanding of what children and adults value and goals are at their shared mealtimes. The study revealed several ways in which value tensions may arise from children's mealtime experiences. Although adults tended to prompt children to sit in their chairs while eating (valuing a low-stress environment), children tended to enjoy moving on and around their chairs (valuing movement, active play, and bodily autonomy). Where adults invited children to use their utensils (valuing the acquisition of life skills), children enjoyed directly engaging food with their bodies (valuing eating on their own terms). While adults hoped children would keep food on their plate (valuing cleanliness), children often relished exploring their food in creative ways (valuing imaginative play). Yet, neither these expectations nor the conditions they valued proved entirely

opposed. I witnessed adults acknowledge and support children's movement on chairs and appreciate children's playful experimentation with their eating approach (within limits). Even as children and adults articulated conflicting goals, those goals seemed to work in tension, shaping the mealtime experience in meaningful ways. Through iterative rounds of data analysis, I showed how these observations could be used as inspiration for designing technology for mealtime. I will describe technology design more in the remaining chapters.

3.3.1 *Playful Productivity*

With these observations and prototypes in mind, I turn to broader lessons for the HCI community that come out of this work around playful productivity, a concern for design within heterogeneous groups. Here, productivity around mealtime was not merely a matter of reaching instrumental ends such as learning how to use a fork. Instead, it was entangled with emotional play and creative exploration. As teacher P10 mentioned: "*creativity [is] not restricted to what would be defined as the arts. It's throughout our day.*" This conceptualization of creativity is reminiscent of the Montessori teaching philosophy, which labels what is commonly referred to as "play" as "work" to reflect the purposeful and valuable nature of children's play activities [16]. I see this insight as pointing to the possibility of moving beyond a playful-productive dichotomy (separating the child's interests from those of the overseeing adult) and opening opportunities for developing playful productivity as embodied in the stamp plate.

Like traditions of constructivist learning [97], designing for playful productivity might highlight the development of important knowledge and understandings through everyday acts of creative construction. This observation suggests attending to how value tensions become, as Houston et al. [58] point out, "process[es] by which value (and valuation) are achieved, sustained, and evolved through time," but also processes that may serve as key opportunities for design. This

design-orientation toward value tensions as always in motion—produced, maintained, and adjusted through practice—complements a rich body of work exploring the possibility of playful interaction without concerns for efficiency, ease, or speed around digital technology (see [105,108,114,123]). Pushing beyond slow or ludic concerns, our work suggests attending to tensions in value as routine accomplishments made possible with and through expressions of embodied creativity. When I examine playful productivity within this frame, I deepen our understanding of how value tensions work as materially embodied processes, as one of many conditions that require care and repair through sensory engagements.

Chapter 4. UNDERSTANDING PARENT'S PERSPECTIVES ON MEALTIME TECHNOLOGY

Using the formative work in chapter 3, particularly part 2 (observations at home), which illustrates the four themes parents care about when they have mealtimes with their children (healthy eating habits, eating more food, table manners, and mealtime conversation), I am interested in learning what technological engagements parents think are appropriate to embed in young children's mealtimes.

I created storyboards presenting novel design solutions, one for each of the three form factors (for a total of 12 storyboards altogether). I conducted a survey with 122 parents of preschoolers soliciting their reactions to all 12 storyboards (four design opportunities addressed with each of three form factors). Form factors included: 1) screen-based designs, as screens remain the dominant design paradigm for consumer-facing technology, 2) smart object designs, partly because UbiComp prototypes for family meals frequently take this approach and embed design solutions into the surrounding environment (e.g., [15,29,37]) and partly because I want to understand whether parents' interest in integrating technology for meals would differ between a multi-purpose platform like a mobile phone and a technology tailored specifically for this context, and 3) voice interfaces, both because these are the fastest-growing consumer-facing technology—projected to be in 50 million homes by the end of 2018 [25]—and because they offer a different modality from other common technologies, potentially removing certain adoption barriers or adding others. Although a number of other form factors (e.g., haptics or wearables) would also be worthy of exploration, I curated this particular set to create a range of diverse solutions while keeping the set of scenarios manageable and focusing on formats that have seen the most uptake in this domain.

With this work, I hope to provide designers interested in family meals with a more nuanced understanding of how parents might respond to novel design solutions for this space.

4.1 METHOD: SURVEY DESIGN

After completing analysis of interviews and observations, I used these four themes to form the backbone of a survey probing parents' interest in adopting various technologies for meals. Here, I describe the storyboards I created as a team as prompts to understand their interests, the larger survey in which these storyboards were embedded, and parents' responses to the final instrument.

I first recruited a group of volunteer designers—all current students with a background in design—to help generate design concepts for the survey. I iteratively brainstormed and refined ideas for each of the 12 different categories (see Table 4.1). To understand how parents felt about using each of the three different types of technology (screens, voice interfaces, and smart objects), I generate one storyboard for each meal-time goal for each type of technology (i.e., three storyboards for each of the four meal-time goals). The storyboards build on traditions of speculative design[27,99] that position possible futures as sites for examining technological developments in the present. Drawing from early literary traditions of speculative fiction [e.g. [50]], these approaches typically rely on visual or material manifestations of seemingly far off worlds to provoke reflections on the broader social consequences of computational visions today[37].

Table 4.1. The specific technologies presented in the 12 user scenario storyboards shown in my survey. Parent goals are shown in pink, and the technology form factor is shown in green.

	Encouraging Healthy Eating Habits	Encouraging Eating more food	Encouraging Normative Table Manners	Encouraging Mealtime Conversation
Screen	A video about a carrot telling stories of itself that plays before the meal.	A bear figure that appears on screen to count the bites that a child takes with a parent before dinner.	A screen-based game that incentivizes a child to take up a set of customizable table manners.	A family photo that automatically pops up on a shared screen with the mention of a related moment in dinner conversation
Smart Object	A plate with an embedded adjustable food pyramid; the child can make different parts light up by eating corresponding foods.	A smart fork that detects what a child eats, prompting the child to ask others at the table to eat a specific food.	A cat face shaped plate with a matching cat fork. When the child uses the fork to eat, parts of the cat plate light up.	A chair buzzes to indicate that its occupant should take a turn starting a new conversation.
Voice interface (Amazon Echo)	An Echo Skill that reports the food a child has consumed for the past few days to help parents decide what to cook for dinner.	An Echo Skill that reminds children to eat intermittently.	An Echo Skill that reminds children to sit at the table intermittently throughout dinner.	An Echo Skill that listens to the conversation, asks follow-up questions, and asks children who are quieter about their day.

I embedded each of the 12 storyboards in an online survey, displaying each illustrated storyboard and several follow-up questions. Each storyboard was intentionally presented in hand-drawn form, with the aim of eliciting more honest feedback by presenting the concept with very low fidelity. For each storyboard, I posed the open-ended question, “*What do you like and dislike about this idea?*” along with several quantitative questions asking parents about their interest in trying the design idea I presented, the extent to which they felt the design idea was appropriate, how much they liked the idea, and whether they felt having this tool would change their likeliness

of using technology during meals. I also included general questions in the survey about families' technology use and attitudes about technology during family meals.

I recruited parents over the age of 18 currently living in the United States with at least one child between the ages of two and six to complete my survey. I asked parents to reply only if they eat meals together with their child at least twice a week on average. I recruited a convenience sample through social media, email lists, parenting groups, and word of mouth. Respondents were geographically diverse and represented 37 U.S. states; they were also almost entirely female (93.3%) and over-representative of middle-class families. I received complete responses from 122 parents. All respondents had the option to enter a drawing for an Amazon gift card for US\$10 as a thank-you for their participation with one in five odds of winning.

To analyze survey responses, I first compared quantitative responses to each technology type and each meal-time goal using SPSS statistical software. I performed a qualitative open coding of parents' text descriptions of their reactions to each storyboard, examining open-ended responses in light of my quantitative results. I took each qualitative response from each storyboard and iteratively refined an affinity diagram for each of the 12 storyboards, clustering example quotes into salient and increasingly precise themes. To understand commonalities across each of the three technologies and each of the four goals, I laid out the corresponding affinity diagrams and examined the themes that held across them. Later, I examined each quote and used structured content analysis to determine which themes were more salient across the three forms of technology.

4.2 SURVEY RESULT AND ANALYSIS

4.2.1 *Quantitative Comparisons of Parents' Responses*

To understand parents' preferences about using different types of technology to address different mealtime goals, I conducted a two-way repeated measures ANOVA with technology-type (screen, voice interface, IoT) as one factor and goal (eating healthy foods, eating more food, using specific manners, and engaging in conversation) as the other. my dependent measure was parents' response to the question: "*My reaction to this scenario is...*"

The ANOVA revealed a significant main effect of technology type $F(2, 121) = 26.12, p < .001, \eta_p^2 = .176$. Post hoc analysis revealed that regardless of the type of mealtime goal, parents' reactions to screen-based technologies ($M = 3.06, SE = .06, 95\% CI = 2.93, 3.18$) were significantly more positive than their reactions to IoT-based technologies ($M = 3.33, SE = .07, 95\% CI = 3.20, 3.47$). And their reactions to IoT-based technologies were significantly more positive than their reactions to voice interface technologies ($M = 3.58, SE = .07, 95\% CI = 3.44, 3.72$). A Bonferroni correction was applied to all comparisons.

This ANOVA also revealed a significant main effect of goal, $F(3, 121) = 65.27, p < .001, \eta_p^2 = .349$. Post hoc comparisons revealed that regardless of the type of technology, parents were significantly more interested in using technology to encourage healthy eating choices ($M = 2.80, SE = .07, 95\% CI = 2.66, 2.94$) than to encourage table manners ($M = 3.16, SE = .07, 95\% CI = 3.03, 3.30$). And they were significantly more interested in using technology to encourage table manners than to encourage eating more ($M = 3.68, SE = .07, 95\% CI = 3.54, 3.82$) or to encourage conversation ($M = 3.65, SE = .07, 95\% CI = 3.51, 3.79$). A Bonferroni correction was applied to all comparisons. The interaction between technology type and goal type was significant but of small practical relevance ($F(6, 121) = 3.179, p = .004, \eta_p^2 = .025$).

I re-ran the repeated measures ANOVA using each of the other acceptance measures I collected (likeliness of trying a product, appropriateness of the product, and impact on technology use) as the dependent measure. In all cases, the same pattern of significance persisted, wherein parents were more accepting of screen technologies than IoT technologies, and more accepting of IoT technologies than voice interface technologies.

Despite these significant shifts by form factor, it is worth noting that there were participants who embraced and who rejected each of the three form factors. Across all participants 39% had an average reaction to the screen-based scenarios that was positive, 19% neutral, and 42% negative. For smart objects, 26% of participants had an average positive reaction, 18% neutral, and 56% negative; for voice interfaces, these were 23% positive, 6% neutral, and 71% negative (see Figure 4.1). These responses reflect differences across form factors, and they also highlight that although a majority or plurality of respondents had a holistically negative reaction to each form factor, a non-trivial minority were interested in each type of technology as a tool for meals.

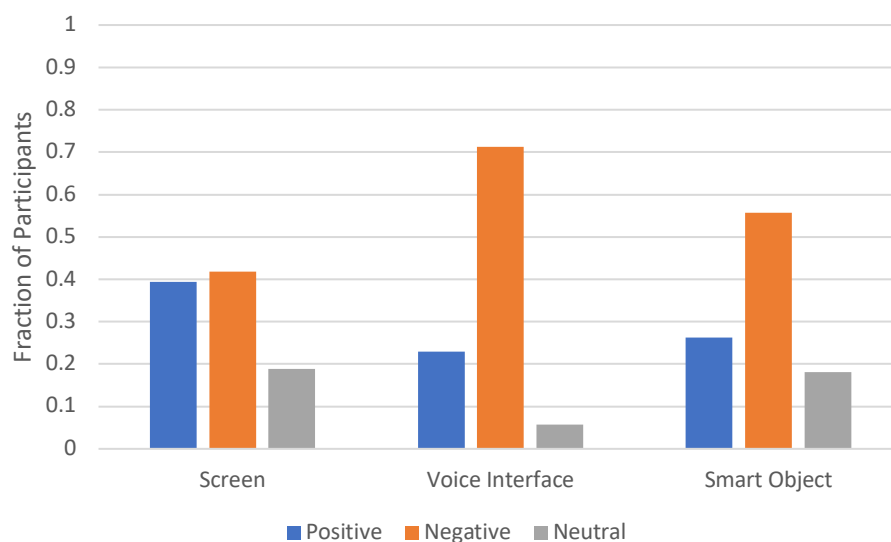


Figure 4.1. Fraction of participants who responded, on average, positively, negatively, and neutrally to scenarios for each form factor.

4.2.2 Adoption Barriers and Parents' Concerns

In their open-ended responses, parents raised a number of concerns in reaction to these storyboards that clustered into four overarching themes: control, distraction, dependence, and intrusion (see Table 4.2), as well as a hierarchy of subthemes. Parents pushed back on some scenarios, saying they gave technology too much authority (control), and rejected others because they felt it would draw the family's attention away from the meal, the food, and one another (distraction). In some cases, parents explained that they viewed dependence on technology as problematic in its own right and worried that adopting one of these designs would increase their long-term technology use (dependence). And in some cases, parents rejected the design because they felt it represented an intrusive or creepy presence that did not belong at their dinner table (intrusion). Although all themes surfaced with all form factors, they were not represented evenly. Figure 4.2 shows the fraction of participants who brought up each concern with each technology, and in the following sections, I describe concerns and adoption barriers with respect to each form factor in participants' own words.

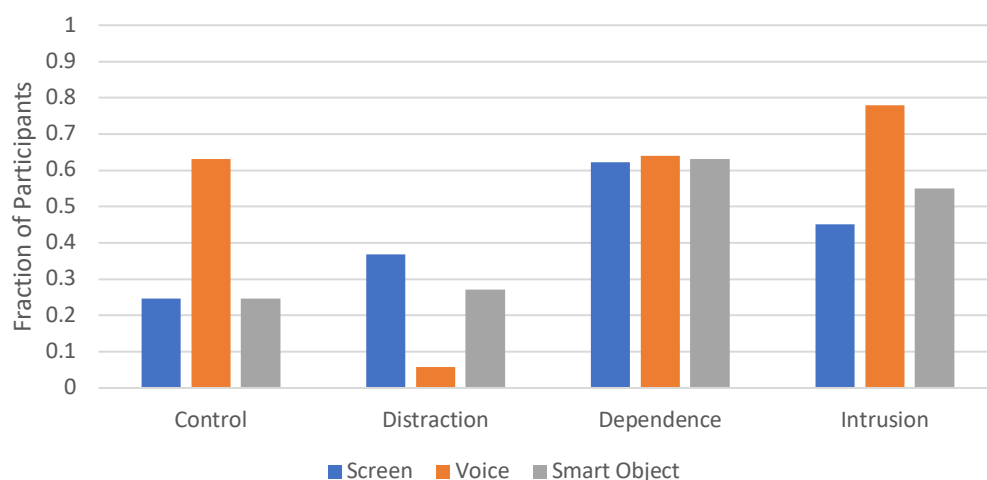


Figure 4.2. Fraction of participants who brought up concerns in each of four main categories when responding to storyboards for each type of technology.

Table 4.2. Descriptions and examples of top-level concerns that parents expressed (each of which had several sub-codes).

	<i>Description</i>	<i>Example</i>
<i>Control</i>	Technology should not encourage or tell children what to do, be in control, make decisions, or direct users.	<i>“I do not like the idea of eating reminders. It builds reliance on technology rather than someone's natural body cues of hunger.”</i>
<i>Dependence</i>	Using the proposed design would lead to problematically more technology use.	<i>“I don't like that a child could come to really like this and see it as a pattern and have a meltdown if they don't get the special video before dinner.”</i>
<i>Distraction</i>	Any mention about technology being a distraction or pulling family members attention away from something the participant feels is more deserving of that attention.	<i>“However, I am a bit concerned that the buzzing may disrupt an ongoing conversation.”</i>
<i>Intrusion</i>	Intrusion, creepiness, or inappropriate presence of technology.	<i>“More technology replacing humans. More humans giving away their voices and giving up their private sphere/home/lives. Guess who keeps all these voice commands?!”</i>

4.2.3 *Voice Interfaces: Creepiness, Intrusion, and Replacement*

Parents Concerns about control, dependence, and intrusion were all common in parents' responses to voice interface scenarios. First, parents frequently explained that they did not feel technology should tell a child or an adult what to do or direct a user's behavior. This sentiment persisted regardless of the type of goal the design was intending to address. For example, in response to my design to encourage table manners, parents said things like: *“I don't love the idea of a machine being so directly involved in managing kids' behavior”*; in response to my design to encourage eating more, parents said things like: *“I don't want my daughters to learn to take direction from a computer”*; in response to my design to encourage healthy food choices, parents said things like: *“I have control over technology...I want to make my own decisions”*; and in

response to my design to encourage conversation, parents said things like: *“The responsibility of directing and contributing to conversation should be on PEOPLE, not technology.”*

Across all voice interface scenarios, the sense that technology would exert an inappropriate amount of control or influence over their family’s choices was one of parents’ most common concerns, raised by roughly two-thirds of participants. Although parents brought up this sentiment in response to screens and smart objects as well, they were more than twice as likely to express it when they discussed voice interfaces. In doing so, they frequently ascribed agency to the technology or suggested the interface would become a replacement for their own cognition, saying things like, *“[I] can make decisions without a robot”* and *“People who use these devices are not thinking; why not use one’s brain to figure out what to eat?”*

In line with pushback against device authority, many parents expressed concern that incorporating these voice interface solutions into a family context would lead technology to take over work that should be the exclusive burden of a parent. Parents said things like, *“This is the parents’ job, not Echo’s,”* *“I am strongly opposed to using technology to assume the role that a parent is supposed to take,”* *“I don’t like [that] Echo is nagging kids. It is MY JOB lol,”* and *“NO NO NO. It’s MY job to help my kids become healthy eaters and have a positive relationship with food. I’m not passing that responsibility off to technology.”* In some of these instances, parents’ statements even reflected an explicit fear that the voice interface might become more powerful than the parent or in some way take over the parent-child relationship, saying things like, *“I’m uncomfortable with kids having a caregiver relationship with Alexa,”* *“It seems to grant Echo higher status than the parent,”* and *“Isn’t this giving technology a role in parenting that might undercut the parent at another time?”* Overall, 48% of parents responded to at least one voice interface design with a statement that reflected concern that the technology would take on parent

responsibilities. In contrast, only 10% of participants mentioned concerns about a screen replacing the parent, and only 7% mentioned it with respect to smart objects.

Relative to the other technologies I presented, parents' responses to voice interface scenarios also reflected greater concerns about surveillance and intrusiveness. Respondents made comments such as, "*Alexa is corporate surveillance,*" "*I am generally creeped out by passive listening by a voice interface,*" and "*I just can't get past the creepiness of these systems.*" Calling the speaker system "creepy" spoke to a prevalent concern that the voice interface remained on and listening to family conversation in the background without the parent's explicit consent.

4.2.4 *Smart Objects: Ubiquity and Physical Safety*

I saw that the smart object designs I presented elicited common responses from parents, despite their varied designs. As with all form factors, parents worried that children's immersion in a world of connected objects would result in greater technology dependence. They spoke of the smart plate saying, "*Why would I want to become THIS tech dependent?*" and of the smart fork saying that, "*it might make meals without their special fork even more difficult*" or "*this is TOO MUCH tech at the table.*" They reacted to these smart objects saying things like, "*my son would like this...but he might rely too much on it and refuse to eat off other plates.*" Embedding technology throughout the child's environment and across everyday objects left parents concerned that their child would be become dependent on a digitally enhanced world and dissatisfied with an analog one.

Parents also associated smart object designs with distraction. By embedding digital support into everyday objects, parents worried that children would attend to the objects more than they otherwise would and neglect important aspects of family meals. Parents reacted to the smart chair by saying, "*it would be a real distraction from eating dinner,*" and "*it might make a meal time fun, but it creates too much distraction.*" They described the enhanced smart fork as "*gimmicky,*" and

said things like, “*I think the fork might help little ones learn their foods, but I don’t like that it might distract them,*” and “*if it has a button, [the] kid would just push it all dinner.*” They worried that the smart plate would, “*end up being distracting*” or be, “*more distracting than useful.*” By introducing new digital features into everyday objects, parents felt these technologies would redirect children’s attention away from food, eating practices, and person-to-person interaction. Parents were five times more likely to bring up concerns of distraction with smart objects than with voice interfaces.

Finally, smart objects were the only designs that elicited concerns about practical and tangible considerations related to integrating technology into the physical world. Parents said that they worried about having electricity in a plate for safety reasons, said that they imagined the plate would be “*hard to clean safely,*” and they were sure, “*it’s not going to be dishwasher safe.*” They described the smart fork saying would be, “*high maintenance,*” “*difficult to clean,*” “*contain non-food-safe components,*” and “*like to smudge [or] break.*” Across scenarios, parents felt that smart objects were attempting to take on tasks that required practicality, ruggedness, and durability for which electronic objects are not suited, making them a poor fit for meals.

4.2.5 *Screens: Familiarity, Dependence, and Distraction*

Of the three types of technology I tested, parents were most accepting of my storyboards depicting screen-based designs. These scenarios were the only ones that parents described as familiar, and 16% of participants responded to at least one screen-based design by spontaneously mentioning that it was reminiscent of something they already do in their home in relation to meal time. For example, several parents mentioned watching episodes of *Fizzy’s Lunch Lab*, *Sesame Street* and other educational programming to encourage their child to engage with different foods. In response to a screen-based design to encourage healthy choices, one parent explained, “*There was a Daniel*

Tiger episode like this and the benefit was felt even though it was watched days before the challenging food item appeared.” In response to a screen-based design to encourage conversation, other parents said, *“my husband sometimes does this, like the display pad, he would find photos for reminiscence,”* and *“sometimes I do something similar or related: look up videos or pictures of something I are talking about (spaceships, volcanos, etc).”*

Similarly, other parents responded to screen-based storyboards by saying things like, *“I do this sometimes with YouTube already”* or *“I have done a version of this with my children where I introduce them to the Abby broccoli song and sing it together when I eat broccoli.”* Across all four scenarios, parents expressed more familiarity with screens than with the other two form factors I presented, and in doing so, they voiced greater comfort with the technology and described positive experiences they had had in the past. This connection to screen scenarios contrasted with smart objects and voice interfaces, which parents did not reference as a part of their current mealtime practices, suggesting the potential for the novelty of smart objects and voice interfaces to be at least a partial contributor to parents’ speculative fears.

Despite their familiarity and acceptability relative to other form factors, parents’ reactions to screen-based interfaces were still more negative than positive. As with smart objects, parents frequently brought up the likelihood of screen-based designs distracting children from important parts of the mealtime experience. For example, parents responded to the design to encourage table manners saying, *“it would end up being a distraction during the meal,”* and to the design to encourage conversation saying, *“I don’t like it when tech interrupts normal interactions and draws attention to itself.”* In these cases, parents explained that they dislike the, *“presence of distracting device [that] will no doubt lead for demands to do other tablet/phone activities.”*

Similarly, parents also brought up concerns about screen-based solutions increasing their family's technology use and dependence. For example, parents explained, *"I don't like that a child could come to really like this and see it as a pattern and have a meltdown if they don't get the special video before dinner,"* *"I still dislike this a bit because it feels like using a crutch,"* and *"What do you do when you are not home [with the technology] and the child is supposed to eat something?"* These statements and others reflected concerns about children and parents alike becoming dependent on digital tools for meals, and they highlighted worries that such tools would act as a gateway to ever more technology engagement. Parents described this technology creep by calling it, *"a Pandora's Box. Once you start letting your children use one digital device, you can't control them anymore. They will just keep asking for more."* Drawing on their past experiences with screen-based devices, parents said that once they allow smart devices into the home, they become difficult to contain. I heard this concern echoed in responses I received from other participants who did not finish the survey, citing not wanting to use technology during children's mealtimes at all. None of the scenarios applied to them, they explained. Once technology slips into a child's life, they felt it would create an irreversible shift in daily life.

4.2.6 *Appreciating Technology at Meals*

Despite this robust set of concerns, a sizeable minority of parents expressed at least some interest in the designs I presented and some amount of willingness to integrate each form factor into their family meals, suggesting that these adoption barriers are not universal and perhaps not insurmountable. The aspects they valued were less thematic than the aspects that worried them, and participants often explained what they liked by describing its contextual relevance to their own family, for example, valuing designing to encourage conversation because *"my husband is not a big talker."* A minority of participants expressed interest in the designs that seeded conversational

topics or provided other anchors for joint family attention. One parent reacted to the voice interface design to encourage conversation saying, *“I like that it could help generate conversation ideas when conversation is low, and could help get around not wanting to answer parents' questions directly,”* and another commented on a screen-based interface with context-specific images to prompt conversation saying that it, *“reinforces something the family is already doing in a natural way.”*

The most popular design was a screen-based solution to teach children about healthy foods. A sizeable minority of parents also expressed interest in trying it, citing their desire to increase the diversity of children’s food consumption and their appreciation for the fact that this approach could decouple the timing of the intervention from the timing of the meal (*i.e.*, so that technology would not be present during the meal itself). Parents explained, *“I like this as long as it's happening before dinner and therefore not distracting,”* and *“it's not at the dinner table, which is more positive.”* Many of these statements expressed appreciation for the scenario, yet still surfaced the concerns of parents who rejected the scenario (such as distraction or dependence), saying things like, *“I do think it's good that the show is educational, but I worry that my child may want to keep watching once the video ends,”* and *“I like the learning about food, which might help kids appreciate their food more. I don't like that it might set up an expectation that there is always a video before meals.”*

4.3 DISCUSSION OF THE FINDINGS

Consistent with prior work, I found that participants often expressed concern about the idea of integrating technology into family meals—even technology designed explicitly for this specific use case and in service of common meal-time related goals. However, my results reveal that these concerns take several different forms, and the way in which designers package tools for this context may predict different adoption barriers. Families anticipate voice interfaces blending into the

background without causing distraction, but intrusively inserting themselves into intimate parent-child relationships. Screen-based interfaces were more familiar and therefore more appealing. Designs that could support mealtime habits without being a part of the meal itself were more acceptable.

4.3.1 *Dependence and Distraction from Ubiquitous Technology*

Despite this variety, all three of the form factors I explored elicited concerns that their adoption would lead to increased technology use and dependence. This was true of screen-based designs, which parents thought might act as a gateway to other screen-based activities, but it was equally true of smart object designs with a dedicated purpose. My work suggests it was not simply the technologies themselves or the contexts of use they made possible but a wider fear of the ubiquity and unrestraint that might follow from their deployment within the home. Participants explained that adopting such designs might lead not only to their use, but to an inability to return to life without them.

Recent scholarship supports participants' fears, documenting intentional design decisions implemented with an explicit goal of capturing and holding user attention [6,22,94,111,115]. For example, Schüll explains that digital gambling machines are intentionally designed to accelerate play, extend the duration of play, and increase the total amount of time (or money) spent [115]. Oulasvitra and colleagues explain how the portable nature of smartphones coupled with design decisions that produce high social and information rewards together make these experiences habit-forming [94]. A number of books act as how-to guides for developers seeking to increase user engagement and compulsive checking habits, supporting the idea that consumer-facing experiences are designed with a deliberate goal of extending use [29,76,89]. Thus, parents' concerns about my designs engendering dependence are consistent with the idea that consumer-

facing technologies are designed to capture and direct the user's attention. In a world where technology provides value to the user in exchange for the ability to exert control over a user's attention, embedding technology in every surface promises to open a Pandora's Box of technology distraction and constant engagement that the user may be unable to close.

Other literature pushes back against such fears, documenting that users experience attention-grabbing technologies as a nuisance rather than an addictive substance [94] and that social narratives about technology as distracting and addictive are unhelpful and unfounded [52]. Lanette and Mazmanian dismantle the pervasive smartphone addiction narrative, pointing out that the link between technology use and clinically defined addictive syndrome is weak, and the typical response to addiction—to avoid the substrate of interest altogether—is likely to be inappropriate with respect to technology [70].

My work contributes to this discussion by suggesting technology designers consider the fears of control, incremental creep, and dependency that ubiquitous tools pose out of the box for parents, particularly as such technology intertwines with the most intimate spaces of family life. Contributing meaningful designs in this context may require designers to demonstrate that they can offer bounded technology use in partnership with parents. With respect to meals, I see that these concerns are particularly salient for parents, heightening the need for designers to build trust with their users when creating experiences for this space.

4.3.2 *Personification in Family Contexts*

When reacting to voice interface designs, a majority of participants spontaneously brought up concerns about the idea of technology taking control or intruding inappropriately, concerns that arose less often with other form factors. And nearly half of participants brought up these concerns by explicitly describing the interface as problematically taking on parenting responsibilities.

Although I presented scenarios that included surveillance and data gathering using all three form factors, parents' reactions were severe in the case of the voice interface, where the results of this surveillance were reflected back to families through a humanoid voice. Parents spoke about this humanoid actor as an intruder, saying she should "*mind her own business*" and raised concerns about their child being controlled or manipulated by a technology.

These reactions should be interpreted in light of the fact that participants are speculating about technologies they have never seen or used. However, they are consistent with other prior work examining the many ways in which users personify smart speakers and other voice interfaces. For example, Perington and colleagues characterize Amazon Alexa, a conversational agent, as an inherently social interactive device, with a name, gender, and personality [102]. They examine user reviews from Amazon Echo's product page and found a correlation between higher user satisfaction and personalization of the device. However, in a qualitative study of 19 users who used Alexa for four days, Lavatovska and Williams found no link between personification and satisfaction. Instead, they described the majority behavior of interacting with Alexa as "mindless politeness"[77].

Our research further examines this question of personification by examining how such technology may assume anthropomorphized characteristics in and around family mealtime, a setting with unique challenges and opportunities related to parenting, nourishment, and child development. My results suggest that adding human-like elements to tools designed for personal family moments may provoke concerns that are less problematic in less intimate contexts. A tool to support family meals that takes on an agentic presence was seen by participants in my study as an intrusive other, rather than a useful tool.

4.4 SUMMARY OF CONTRIBUTION

Here I present a two-part study comprising empirical research and survey data to understand parents' attitudes toward technology during family mealtime. I used four themes that emerged from my formative qualitative studies to design 12 storyboards depicting three types of technology devices (screen-based, IoT object, and voice interface). I then incorporated the storyboards in a survey with parents of young children. My results show that the idea of incorporating technology into family meals raised significant concerns for participants (even when that technology served their mealtime goals). Yet, I also found that responses varied depending on the form the technology took. Participants expressed an interest in voice interfaces blending into the background but feared they might intrusively insert themselves into intimate parent-child relationships. Finding screen-based interfaces more familiar, they discussed interactions with such devices as relatively more appealing. And all of the designs I presented prompted parents to express concerns about becoming more dependent on technology. With this work, I sought to attune designers to parents' perspectives on technology around meals and the likelihood of these systems appealing to this user group. I highlight parents' concerns of technology prompting intrusion, lack of control, dependence, and distraction, themes that I claim will be relevant for family meals, and may also inform the design of experiences for other aspects of family life.

Chapter 5. DESIGNING AND EVALUATING MEALTIME TECHNOLOGY FOR YOUNG CHILDREN

With an understanding of what values (chapter 3) parents hold and what the considerations parents have with mealtime technology for young children (chapter 4), I turn my focus to how children react to and engage with the technological artefacts in the mealtime arrangements in this chapter.

The goals of this study were, first, to explore the design space of supporting young children's meals through technology, and second, to evaluate the design with children. Some prior work suggests that imposing adults' attitudes on children can have a negative impact on children's eating habits, for example, diminishing their ability to self-regulate and listen to their own hunger and satiation cues [25]. And a large body of work in child-computer interaction has shown that moving beyond the conceptualization of the all-knowing adult and including children's perspectives on the designs is a valuable means of creating technologies that best serve their needs [38].

Thus, I conducted a two-part project to explore the design of technology for mealtimes in preschools that incorporates both teachers' and children's perspectives. I did so using the lens of *value tensions* [23], the conflict that occurs "when supporting one value in a technology challenges another value" [7] in order to surface insights that may not have been captured by prior work with an adult-centric viewpoint. After Houston, et al. [13], I define values as the "the myriad ways in which social and ethical concerns may be built into and out of artifacts, systems, and infrastructures through the process of design." I examined the values held by children and the values held by teachers related to meals at school, and I explicitly looked for tensions or conflicts between these. I then explored how I might design tools that are sensitive to both teachers' and children's needs and sought to help resolve inherent tensions in their perspectives.

5.1 METHOD

5.1.1 *Design Workshops*

After conducting observations and interviews at preschools, I held weekly design workshops as a research group over three months. The research group of six consists of designers, UX researchers and engineers. As part of this workshop series, the group held several sketching sessions to generate design ideas and iteratively derive three key value tensions: (1) sitting still versus feeling comfortable, (2) using utensils versus having autonomy, and (3) prioritizing cleanliness versus prioritizing creativity. I then held two design workshops wherein I used affinity diagramming to group important themes from my original field notes and interview data, followed by ideation and sketching. Together, I used this iterative process of data collection, analysis, and proto- typing to create three smart object prototypes for children’s mealtime in classroom settings (each discussed further in the sections that follow).



Figure 5.1. a) Left: Cat Fork; right: a child using his fork to pick up goldfish cracker; b) Left: The Stamp Plate; right: a child’s stamp plate after he finished eating; c) The Kicking Chair; right: a child

5.1.2 *Participants*

I recruited thirteen 4-to-6-year-old children (six boys and seven girls) to participate in my study via email lists at my institution and at local family housing communities. There are five white and five Asian families, and an African American and a multiracial family in my study [129]. I

evaluated all three prototypes with each child and one or more parents. I also recruited seven preschool teachers to evaluate the three prototypes and participate in a semi-structured interview about the feasibility and usefulness of each of the prototypes. The teachers I interviewed include teachers and teaching assistants in preschool classrooms in a metro area in the United States. The researchers brought the three prototypes, showed the teachers and asked for their thoughts.

5.1.3 *Prototypes*

In chapter 3, I identified three value tensions between children and adults when they have mealtimes together, specifically resulting from observations and interviews in preschools. They are: autonomy vs. utensils, creativity vs. cleanness, comfort vs. sitting still. I find children eat more freely and creatively when they are at school comparing to at home when they are less monitored. Therefore, I created three preliminary prototypes specifically for children, and with adult's preferences in mind. I describe the three prototypes below:

The Cat Fork: The first prototype, The Cat Fork (see Figure 5.1a), consisted of a metal fork and plate that both represent a cat's face. As a child touches the fork to the plate, the connection prompts different parts of the cat's face to illuminate. A total of 10 distinct color lights light up the cat's eyes, nose, whiskers and mouth. My motivation for designing the prototype involved supporting the child's utensil use at the same time as supporting the child's independence. I designed the light interactions to offer children colorful and whimsical feedback while using their own fork and plate together (in contrast to eating off another child's plate or picking up another child's utensils). I built the prototype using an Arduino board and a Makey Makey [16].

The Stamp Plate: my second prototype, the Stamp Plate (Figure 5.1b), comprises a series of stamps that correspond to food items eaten off the plate, leaving behind silhouette-like shapes that create food-inspired illustrations. I designed the plate to record the shape of the food children eat

off the plate and then display that shape much like a lasting shadow. For instance, a cube of cheese leaves behind a square shape next to a goldfish-shaped cracker, which leaves behind a small fish shape. The plate provides children with a space to explore their sensory needs at the same time as supporting caretaker's concern for minimizing mess and keeping food on the plate. I simulated this design concept during my study by having a researcher print pre-designed custom stamps with multi-color inks on an adjacent plate each time the child picked up a snack and ate it.

The Kicking Chair: my last prototype, the Kicking Chair (Figure 5.1c), consisted of a chair with a long elastic band wrapped around to its front two chair legs. Kicking the band triggers a playful sound play. The chair allows children a platform for whimsical expression as they move and wiggle in their seats while supporting caretaker's interest in encouraging children to stay in their chairs while eating. I designed the elastic band to be attachable at any leg height and on any chair (to adjust for child size. To implement the concept in my study, I used two folded pieces of aluminum foil connected to a rubber band, a Makey Makey board, and a laptop. The two pieces of foil touched every time the child kicked the band, prompting a piano note to play.

5.1.4 *Procedures*

Children's Evaluations

To examine responses to my prototypes in practice, I conducted a user study with thirteen children (one at a time) within the spaces they would normally eat their snacks (e.g., children's own homes). I began each user study during the children's regular afternoon snack time and organized the study period as a three-part snack. For each part, researcher(s) asked the children to choose from a selection of snacks to put on their plate (including goldfish-shaped crackers, pretzels, bananas, apple slices, cheese cubes, tortilla chips, and crackers). These snack selections were familiar to children and most of them ate the varieties of food items I provided. The children picked

a new set of snacks at the beginning of each new prototype. I randomized the order of prototypes explored during the study. A parent and a researcher accompanied each child in the study. The researcher occasionally prompted children to share their opinions about the prototype in order to glean a deeper understanding of their experience. I asked children to select their own snacks, but I did not limit or suggest any food items to the children. I tried to make the field trial as naturalistic as possible by letting children eat snacks at their usual snack time and inviting parents to accompany them (following recommendations from Hiniker et al. [56]).

Teacher's Evaluations

I took three prototypes into preschools and show teachers the prototypes during their breaks. I did not let the teacher use the prototypes because they are designed for children to use. Instead, the researchers showed and explained how each prototype works without telling the design processes and intentions. After demonstrating each prototype, I asked what teachers thought about it and how they would use it in the classroom, using semi-structured interview questions. I also randomized the order of the prototype showings.

5.1.5 *Analysis*

I audio- and video-recorded all lab sessions. Members of the research team iteratively watched videos and documented examples of interest using an inductive-deductive approach [15]. Using Trello organizational software, I created cards to represent all examples, creating a dataset of 230 vignettes. I then grouped these data points into themes to create a hierarchical affinity diagram. The teacher interviews were also audio-recorded and transcribed by a third party. I repeated my open-coding process to extract examples and cluster them into themes.

5.2 FINDINGS

5.2.1 *Discovering Affordances*

As children encountered the objects for the first time, most of them took some time to understand how each of the three prototypes worked. In some cases, children understood the

prototype right away, for example, C13 explained “*I want a fish here,*” as he pointed to the stamp plate and then ate a fish from that spot on his own plate. Other children immediately pointed out the connection between the triangle stamp and the chips (e.g., C8) or the half circle to the apple (e.g., C1).

In other cases, children did not immediately discover the prototype’s affordances. Many children did not understand how the Kicking Chair worked even as they used it to produce noises, and in these cases, children claimed the computer, the wire, or the chair itself was responsible for making the instrumental sounds. Eventually, most children came to understand how all three prototypes worked, although occasionally children developed unexpected mental models, such as believing the stamps on the stamp plate represented images of food that other children had eaten (C6).

Once children understood the prototypes, their reactions varied. Some continued to explore the prototype and ask questions, while others focused on eating the food. When children liked the prototype, it was often quite obvious, and they responded with exuberance. C3 and C10 responded to the Kicking Chair by giggling hysterically each time they heard the sound it made. C4 checked the lights on the cat fork and plate as she took a bite carefully and beamed when the light came on. She commented: “*when more lights are on, it [the Cat Fork] is happier!*”

5.2.2 *Influencing Children’s Practices*

Across my observations, I noticed children’s practices change in the presence of the prototypes in four central ways. Here, I describe these cross-cutting shifts.

Increased Eating

Parents expressed that both the Cat Fork and the Stamp Plate led children to eat more food during the study session. C4’s mother commented several times on how much more her child was

eating during the session than usual. And after the study, she remarked: “*Oh my baby ate so much more. Actually, more than what she eats in a whole day!. ...I hope I [could someday] have all these at home.*” In another instance, C1 kept eating many of the goldfish-shaped crackers and pretzels to produce stamp artifacts for these items.

Like the Stamp Plate, the Cat Fork also led children to eat more. C5 wanted to know if the plate made sounds, and he started to eat more from the plate to explore the plate’s capabilities and the effects of eating. C13’s mom claimed the Cat Fork caused her child to eat much more because he liked using it. Another participant, C4, ate very intently using the Cat Fork until all available food was gone. The children tended to keep their attention on the meal while using the Cat Fork.

I asked my child participants which prototype they liked the most at the end of the study, and I asked if they would eat their least favorite food if they could do so using their preferred prototype. While some said they would not, others said they would eat a bell pepper or cheesecake (a non-preferred food) to produce stamps on the Stamp Plate. C3 said she would eat broccoli to make the Cat Fork’s light up. C13 asked for more crackers because he wanted more circles to appear on the stamp plate. And a few children who said they were already full before testing the third prototype still finished the third snack. Parents commented on the amount children ate throughout the session, saying things like, “*She was certainly paying attention to what was happening...that certainly had an impact. She's certainly eaten a lot*” (C3).

Increased Use of Utensils

I observed that when using the Cat Fork, children were more willing to use their utensils to eat. Children were encouraged to explore the fork initially but were not required or continually asked to do so. However, many children continued to engage with the fork and the lights as they ate, even using the fork for snacks that are typically eaten as finger foods. C2 loves cats and when

using the fork to eat an apple slice, she said: “*Guess what? I’ve never used a fork to eat an apple.*” C3 used the fork for every bite on her plate. And several children tried to use the fork to eat the goldfish-shaped crackers or tortilla chips. A few participants gave up on using the fork to eat these challenging foods after several attempts, but most of them switched back to using the utensil when they ate cheese cubes or bananas slices, which were easy to stab.

Prior work reports on children “half using” utensils while eating during typical meals; that is, using their hands to pick up food and put it onto the utensil before putting it into their mouths [11]. Children performed this same action when using the Cat Fork. Although I designed the object in part to address this practice, I saw that children continued to maintain it when using the prototype.

Increased Distraction

While the Cat Fork and Stamp Plate tended to encourage children to focus on their utensils and their food, the Kicking Chair routinely redirected children’s attention away from eating and toward the prototype. Although some children giggled and seemed to enjoy making sounds at the table as they ate, most of the time children either ate or played with the chair but did not integrate the two practices. For example, children sometimes squatted down and used their hands to make sounds by touching the band around the base of the chair, and some alternated between sitting while kicking and sitting while eating.

One child (C3) explicitly stated that the object was a distraction and explained that she was going to use the Kicking Chair to distract her dad, so she could steal his candy. She went on to say she would use it to distract people in public places. C13 believed he should not use the Kicking Chair during meals. He played with the chair initially and then politely asked the researcher, “*Can I eat now?*”

Creative Exploration

I observed that participants engaged in creative exploration when using the Stamp Plate. C1 intentionally continued eating to see the image that the resulting artifacts would form on the plate. C13 wanted a goldfish-shaped cracker on a specific spot on the Stamp Plate, therefore he ate one from the analogous location on his food plate. When I asked why he wanted to eat the goldfish-shaped crackers at that specific spot, he explained: “*cause I want the fishes to pile around.*”

Children also made creative comments as they looked at and reflected on the Stamp Plate after the meal. They made sense of the shapes of the food and created their own stories, which they retroactively fit onto the images they had produced. For example, C3 explained that she had made a pretzel maze for a goldfish to swim through. She went on to describe how she would make a maze using the plate in the future, saying, “*I would turn the plate in the direction I wanted the fish to go in.*” C13 also described his Stamp Plate as a scene deep under the sea, saying that the triangles are sea plants, the circles come from people dropping balls in the sea, while the fish are trying to help give the balls back to the people.

Prompting Self-Tracking

When using the Stamp Plate, several children spontaneously engaged in tracking their food intake. I did not ask the first few children how many pieces of food they had eaten, but I observed that they proactively counted the fish stamps, the triangles, and circles as they were eating, and I were stamping. After I observed this practice in multiple sessions, I modified my protocol to include asking children how much they had eaten. Most children easily linked the composition of the Stamp Plate to the food they had eaten. For example, when asked how many tortilla chips he had eaten, C11 counted the triangles on the Stamp Plate and responded correctly.

C9 reminded the researcher that he had eaten a cracker and that the researcher had not yet placed a corresponding stamp on the plate. Many children similarly pointed to missing stamps if the researcher had yet to stamp the plate, suggesting children found the link between eating and the immediate effect that followed to be meaningful.

5.2.3 *Teachers' Responses to Prototypes*

Teachers' and children's reactions to the prototypes were mostly well-aligned. Here, I describe teachers' general impressions of each of the three prototypes as well as themes that emerged across all of them.

General Impressions of Each Prototype

The Cat Fork: Teachers predicted the Cat Fork would help children develop fine motor skills and encourage them to use utensils. Some teachers felt the Cat Fork may be more appropriate for younger children (under the age of 3) who are learning to use utensils for the first time. A few teachers worried the lights on the plate could be distracting for children and anticipated that children might poke the plate with the fork persistently to see the light.

The Kicking Chair: All teachers loved the concept of the Kicking Chair and thought it was innovative and likely to be engaging for children. However, they did not feel it was appropriate for mealtime and envisioned using it during playtime when it could be the focus of the activity. They predicted 20 children making noise while eating would be chaotic, and a couple of teachers said they already struggle to prevent children from kicking each other's chairs at mealtime.

The Stamp Plate: Almost all teachers felt that the Stamp Plate would encourage children to try new foods and would generate conversation at mealtime, and almost all teachers said that conversations with children are what they value most about meals. For example, T1 anticipated

that children would have conversations with her about how and where the food is placed on the plate. She explained that she could model placing the food, such as putting a goldfish cracker on a plate next to a piece of cheese, and the children might put another goldfish cracker on the plate, this time above the cheese, or to the left of the cheese, fostering conversations about spatial relationships.

They also appreciated the Stamp Plate's support for children's creative expression. T7 commented that she thought the resulting images that the foods left behind on the plate, and the artistic form it would take, could generate many new conversations in the classroom.

Comparing Teachers' Predictions with Children's Actions

In this section, I compare teachers' predictions of how children will react to the prototypes with children's reactions in practice, drawn from my observations during my exploratory evaluations.

The Cat Fork: Teachers expected the illuminating parts of the plate and fork to distract children from their meal. Although a few teachers acknowledged the lights might direct children's focus to the plate, more teachers thought the lights would encourage children to focus on playing with the plate, instead the food itself. T1 said: "*it would be a bunch of kids hitting their plates, and then really causing food to kind of go everywhere.*" Other teachers imagined that the Cat Fork would prompt children to fight with each other at the table, more so than a regular fork. They were also concerned that focusing on the plate would take children's attention away from conversations with others.

In the test sessions with children, I did not observe the Cat Fork distracting children from their eating. On the contrary, most children were pleasantly surprised to discover that the cat plate illuminated. They ate tentatively with their forks to pick up the food, paying careful attention to

which part of the cat plate lit up. Some of the children even used the fork to pick up pretzels (a food commonly eaten with hands).

The Stamp Plate: Children's reactions to the Stamp Plate corresponded to teachers' expectations. Teachers imagined children would make connections between the food they ate, and the images left behind on the plate, and in practice, children were able to do so. Teachers also thought the plate would encourage children to try new foods that they normally would not eat. During evaluation sessions, children expressed willingness to eat foods they do not like in order to generate stamps on the plate. Lastly, teachers expected the plate to help regulate mess and encourage creativity at mealtimes. While exploring the plate, all children in my evaluations kept their food on their plates and demonstrated creative expression, such as storytelling from the stamp-imagery they prompted by eating.

The Kicking Chair: Teachers' predictions about the Kicking Chair also matched children's experiences in practice. Teachers worried about the potential for distraction, a concern that held up when testing it with children. Children would kick and laugh so happily and completely forget about eating; one boy was constantly troubleshooting to see why the Kicking Chair did not work the way he expected and forgot about eating altogether. In addition, teachers predicted the Kicking Chair would decrease conversation at mealtimes. In fact, teachers expressed strong preference for the Kicking Chair idea, but they thought it would be more appropriate to use it other than the mealtime. For example, multiple teachers suggested using it in communal circle time to promote conversation and musical engagement.

5.3 DISCUSSION

I saw that these tangible prototypes offered affordances and experiences that excited both children and adults. And I saw systematic ways in which they shaped children's interactions with and responses to food, such as engendering creative expression and self-tracking and increasing children's willingness to try new things. However, I also observed patterns in which these prototypes undermined meal-time goals and distracted children from the meal itself. And I saw the potential for these systems to persuade children in ways that might undermine their sense of autonomy or disrupt their relationship with the food they consume.

5.3.1 *Tangibles as Tools for Mealtimes*

Across my evaluations, both children and adults told us that the Kicking Chair served as a distraction and undermined children's focus on the meal. Although most children enjoyed engaging with the prototype, and teachers were enthusiastic about incorporating it into their classrooms for playtime, all parties agreed that the chair demanded attention as an object in its own right, rather than as an integrated component of the larger mealtime context.

The Cat Fork and the Stamp Plate designs, on the other hand, allowed children to easily attend to the novel object as a part of enacting existing mealtime practice. Although teachers predicted that the Cat Fork would cause distraction, I saw that by focusing on the fork, children were in fact also focusing on the meal and their eating practices. Children engaged more deeply in these practices than usual, incorporating the utensil into every bite and using a fork for finger foods like pretzels and apple slices.

This distinction suggests that TUIs may support children's meals most effectively when they treat pre-existing materials and practices as first-class priorities and augment existing routines

without upstaging them. Prior work has found that adding interesting but unrelated content to reading materials for children (known as “seductive details” [53]) engages children but decreases their comprehension of and attention to the core material. Similarly, I found that the Kicking Chair created a new experience to attend to rather than augmenting the experience to which the child was already attending, providing design guidance for future TUIs. The Cat Fork, in contrast, added a new dimension to an existing practice, leading children to continue to engage in this practice (eating with utensils) with renewed focus.

These findings also suggest that TUIs may be uniquely well-suited to provide support in mealtime contexts, relative to other forms of technology. Tangibles, by their very nature, integrate with the physical world in a way that goes beyond what stand-alone devices like smartphones and tablets are capable of.

5.3.2 *Value Tensions and Persuasive Tangibles for Meals*

In conducting this study, I set out to explore how I might design for all members of a shared meal, giving the same consideration to children’s in-the-moment values and interests as to adults’ long-term goals for children’s eating practices. I saw that the tangible prototypes I evaluated eased existing value tensions between children and adults and largely encouraged the practices I set out to incite. But these prototypes also surfaced new value tensions I did not anticipate. For example, the Kicking Chair successfully facilitated wiggly play while keeping children in their seats, but it introduced new tensions wherein: 1) children valued attending to the chair and adults valued children attending to the meal, and 2) children valued using the chair as an instrument while adults valued a quiet environment that is conducive to conversation.

Similarly, I saw many indicators that my prototypes incentivized children to change their practices in ways I did not anticipate. I observed that both the Cat Fork and the Stamp Plate

encouraged children to eat more than they normally do, opening serious questions about the consequences of these designs for long-term health and well-being. Many parents and teachers were enthusiastic about this development and felt certain that such tools would increase children's overall food intake. Children themselves gave us insight into the mechanisms underlying this shift in practice. They told us, for example, that they were eating chips not because they were hungry, but because they needed triangles for their picture, or because they wanted LED lights to illuminate. These findings urge caution and suggest the potential for tangibles to promote harmful food-related habits. Persuading children to eat foods they dislike or persuading them to overeat could potentially create unhealthy patterns, such as undermining children's sensitivity to their own hunger and satiation cues. Designing to change children's eating habits without their awareness also suggests the kind of paternalism for which persuasive technology is often critiqued [117]. As work in HCI increasingly acknowledges children as experts on their own experiences [24] and seeks to support their autonomy, it is important for designers seeking to resolve tensions between children and adults to consider how to support children in advocating for their own needs and directing their own practices.

5.3.3 *Mealtimes as Sites for Expressivity and Exploration*

As children engaged with the Stamp Plate in particular, I observed that they used traces of their eating activity to provoke creative storytelling and reflection at the table (see [109]). In designing the Stamp Plate, for example, I had no fixed goals with respect to traditional notions of productivity or education. But by providing children with an opportunity to tap into their pre-existing interest in experimenting and playing with food [11], I inadvertently created an informal learning context in which children counted what they had eaten and linked their artistic creation to their autonomous activities. These insights suggest the potential for tangibles to enhance meals in meaningful ways,

expanding beyond support mechanisms for nutritional goals to opportunities for tangible data sense-making and play.

5.3.4 *Future Work and Limitations*

I see a number of ways for future work to build on the themes I encountered in this study. For example, to further probe whether smart objects can address families' struggles with children's food pickiness while simultaneously respecting children's autonomy, future designs might explore the design of interfaces that make the mealtime experience and the post-mealtime experience equally enticing, potentially encouraging children to eat without incentivizing them to continue to do so beyond their intrinsic hunger. Although I saw behaviors in this initial session that parents said were atypical, I do not know if the novelty would quickly wear off, or conversely, if such a tool might become a problematic long-term crutch. In the future, I hope to study the relationships that children form with these prototypes over time.

The approach enabled me to prototype rapidly and to standardize the environment where children encountered the prototypes. Therefore, the child might be also interacting with the adults presented, and not the stamp plate alone. Other approaches, like Wizard of Oz[81] or more naturalistic setting, might be a clearer separation to test if the child is solely interacting with the prototype. I hope that some of these limitations are mitigated in part by the fact that children regularly engage in meals communally with.

There are also a number of ways in which the context of my study is limited. This data was collected from a small number of individuals in a single metropolitan area who likely did not struggle with food insecurity. Meals, educational environments, parenting practices, and family structure varies dramatically across communities, both within the United States and around the world. The particular experiences I report here are not representative of any larger group. However,

I hope that they generate questions for future designers and yield insights into how those creating future TUIs might engage with this.

5.4 SUMMARY OF CONTRIBUTION

In this paper, I conducted an exploratory evaluation with children and teachers to gather their feedback on three TUI prototypes designed to resolve adult-child value tensions in mealtime contexts at home and at school. My results show that although my prototypes addressed certain value tensions, they seemed to ignite new ones, highlighting the complexities of value alignment in practice. The effectiveness of these novel tangibles in changing children's behaviors prompt us, as designers of technology, to consider what I do when I seek to address value tensions. I see how designers may nudge users with competing perspectives toward a compromise in ways that unevenly respects the parties involved. In view of this work, value tensions invite not quick resolution but thoughtful consideration of whom designers seek to persuade and why. In this sense, my findings also offer insight into the ways TUIs may shape children's practices in mealtime contexts by offering prompts to designers who seek to do so with care.

Chapter 6. STAMP PLATE: TECHNOLOGY FOR FAMILY'S MEALTIME WITH YOUNG CHILDREN

Learning that the stamp plate prototype designed in chapter 5 not only supported children to focus on their food, but also catalyst creative expressions and self-tracking behavior, I proceeded to develop the stamp plate into a more functional digital prototype and deploy it at young children's homes in the final phase of my dissertation.

I studied how children from 3 to 6-year-old use the stamp plate to eat along with their parents and siblings. This work aimed to answer RQ 3: "*How do specific technological features support both children and adults to address value tensions at their mealtime?*" and RQ4: "How do technology engage children, adults and digital artefacts to create meaningful experiences at this mealtime contexts?" In this chapter, I describe how the stamp plate is designed and the details of the field studies of deploying the stamp plate. Then, I lay out the findings of the interactions around the stamp plate among family members and discuss how these findings inform the answers to my research questions.

6.1 STAMP PLATE DESIGN

Using my previous participant observation of family dinners with children aged 3 to 6 years old, and design insights from a lab testing with a preliminary prototype[13], a team of designers and engineers and I created a digital prototype of a stamp plate to support children's data engagement at mealtimes with their parents. We then iteratively developed and revised the stamp plate prototype which we implemented with an Arduino board and a weight sensor. In this section, I describe how I designed and implemented a smart plate called a "stamp plate" for all the family members to use at their mealtimes, including preschoolers, their siblings, and their parents.

6.1.1 *Stamp Plate Hardware Design*

I developed a high-fidelity implementation of the stamp plate, which I deployed on a Samsung tablet device, augmented with a weight sensor (see Figure 6.1). To enable the plate to display a stamp on the position where the child picked up the food, the research team had to implement a mechanism to sense: 1) that the child has picked up the food from the plate, 2) the type of food they picked up, and 3) detecting the position where the food item had been.

We tried several approaches to enable such interaction. I first attempted to use computer vision to determine the type of food its position on the plate screen. However, this approach required an external camera, which in turn required a calibration step and left performance vulnerable to lighting fluctuations and other external visual factors. I also explored object tracking solutions[4], but found that most object tracking techniques require additional tags to be attached to the tangible objects. For example, for vision-based tracking, tags such as ARTag [35] or QR code[30] would be added to the object, an approach that is incompatible with edible objects to be consumed as part of the main usage scenario. Similarly, techniques like electromagnetic sensing [31] require attaching an additional circuit to objects.

Ultimately, I used the capacitive touchscreen of a tablet computer coupled with a weight sensor to detect food placement and users' eating behaviors. The touchscreen could be used to sense if the child has picked up the food from the plate. The weight sensor is used to identify the type of food the child picks up. To achieve this, I “pre-programmed” the food provided to the children. I cut each food item into a similar size for each piece to fall into the same range of weight, which triggers the weight sensor to display the corresponding stamp (bread - brown square; apple - red semi-circle, cheese – yellow triangle).

I used an Arduino Uno and a 5kg load cell with an HX711 amplifier to transfer the signal to the Android tablet (Samsung T280 with a 7-inch screen). Considering the different forces of each touch and the minor differences between each food item, my current design limits us to only provide 3 different types of food for an optimized result. Each of the foods is a different given weight which differs by at least 2g. The food items are distinguished by their color, shape, and weight. They are apple slices(10g), cheese cubes(5g), and bread slices(1g). The food items are placed on the tablet screen and the child picks up the food from there. The food is conductive. Touching the food on the tablet surface triggers a touch release action which triggers the system to start counting the weight change and displays the food stamps on the screen. Although it does not require the user putting the food in their mouth to surface the stamp, I thought the interaction still intuitive enough that participants would put the food into their mouth right after they picked it up. The field study also showed this was true, and I only had a couple of instances where the child picked up a food item and waited to see what happened. All the adults ate the food after they picked it up.

The purpose of this prototype is not of the value of a technical contribution to this particular technology. Rather, I am using the prototype to investigate how parents and children interact with a smart object at mealtimes, as well as how such an object can not only fit into their current family routine, but also create moments of meaningful experiences among them.

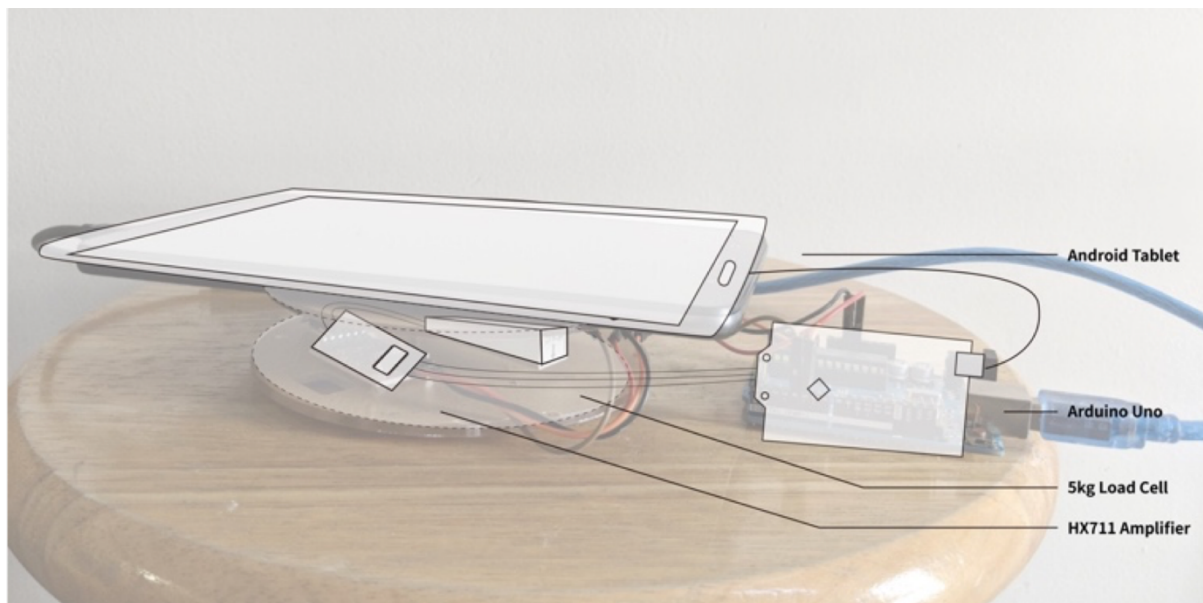


Figure 6.1. Stamp plate hardware.

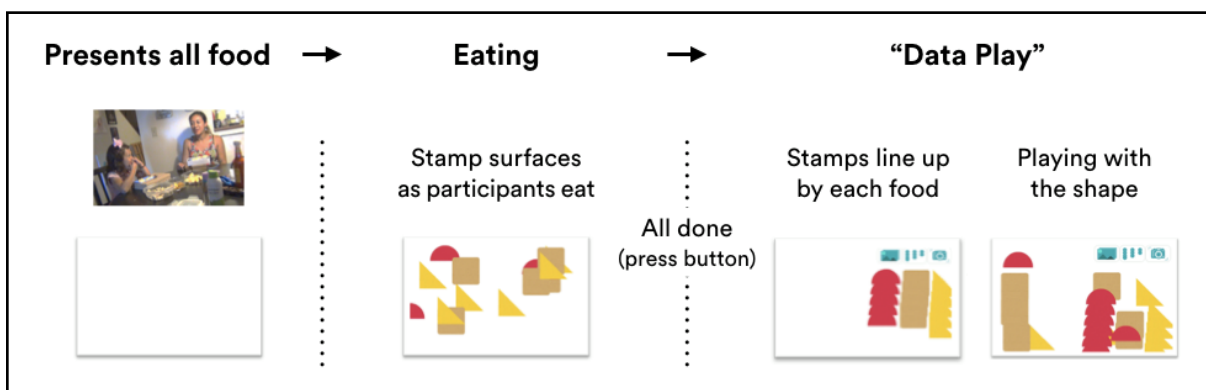


Figure 6.2. Stamp plate software Design

6.1.2 *Stamp Plate Software Design*

The stamp plate is meant to look like and be used as a plate, therefore I designed the interface to be clean and clear to the participants, resembling a white plate surface (see Figure 6.2). Before the participants started eating, the stamp plate screen is a white background, representing an empty plate that invites the participants to put the food on the plate. As they pick the food up, the weight

sensor identifies the weight loss and the plate shows a stamp on the corresponding spot where the food was picked up.

After participants declare they are all done with eating, researchers enacted the “All Done” button which prompts the stamp plate to go into “data play”. I originally designed the “All Done” button to be shown on the plate while participants are eating, but I quickly found out during my testing session that it was likely to be touched and activated accidentally, and it was also inviting for children to press it just out of curiosity. With these behaviors in mind, I decided to use “Wizard of Oz”[81] just for this feature: I hid the button, and it was only activated by a researcher by tapping the certain spot on the screen 5 times to minimize unintentional activation instances.

In “data play”, all the shapes line up by each food item on the left side of the screen. Participants can move the shapes on the screen to create their own expressive art. At this stage they are already done with eating. The stamp plate is used as a regular tablet and they can use their fingers to interact with the interface. Stamps cannot be moved before the “All Done” button is pressed, but in “data play” they can. Participants can decide if they want to eat more food by going back to eating and make the screen a plate surface again. I designed it this way because I wanted to give participants the autonomy to decide if they want to go back to eating.

The three icons on top of the lined-up stamps are “take a screenshot”, “line up the stamps”, and “pictures” (right to left). Participants can press the camera icon to take a screenshot any time they want to capture their artwork on the screen. And if they want to start their artwork all over again, they can press the icon with the lined-up dots. They can see all their screenshots by going into the photo gallery (picture icon).

6.2 METHOD

6.2.1 *Participants*

I visited fourteen homes of families with at least one child between the ages of three and six and gave each of the participants a stamp plate. In total, there were 19 children in my study, with one child who was 7 years old and one child 2.5 years old who are siblings of a 3 to 6-year-old child (see Table 6.1). There were 15 parents in my study. There was one family where both parents (father and mother) participated, and 14 of the other participating parents were female. my child participants included 9 girls and 10 boys. I recruited the participants through the university housing mail group and closed social media group, and through the institutional mailing list. Because most of the participants are from university family housing, my participants are comprised of diverse ethnic backgrounds, including Asian, Hispanic and Caucasian. And although all participants live in the Seattle area where I conducted the field study, they come from diverse cultural backgrounds.

Table 6.1. Participants info and how strongly suggested relationship between behavior and data

Children	Age	Behavioral and data relevance	Parent's help
P1 - a	5	Yes	Strong
P1 - b	2.5	Not quite	
P2 - a	4.5	Yes	Strong
P2 - b	3	Not quite	
P3 - a	6	Yes	Moderate
P3 - b	3	Yes	
P4	4	Yes	Strong

P5	3	Yes	Moderate
P6	4.5	Not quite	Moderate
P7	4	Yes	Strong
P8 - a	3	Yes	Moderate
P8 - b	5	Yes	
P9 - a	5	Yes	Moderate
P9 - b	7	Yes	
P10	4.5	Yes	Weak
P11	4	Yes	Moderate
P12	3.5	Not quite	Strong
P13	4	Yes	Moderate
P14	6	Yes	Weak

Strong influence: Parent directly suggests that when the child eats a food item, the corresponding shape appears.

Moderate influence: parent involves and guides the child in figuring out the relationship, without directly telling the child food and stamp relevance.

Weak influence: Parents only mildly involved in the process (i.e. asking a few questions).

6.2.2 *Materials and Procedures*

We went into participants' homes and asked them to eat where they normally have their meals. I prepared three food items for the study: cheese, bread pieces, and apple slices. I asked each family when they signed up for the study if they had any food allergies and offered to prepare alternative food items if they had one. None of my participants reported any food allergies. The food was freshly prepared right before every study session. Participants were instructed to eat the food and interact as they normally would during their mealtimes together. And because the food is more suitable for snack time, I asked participants to schedule the study around their snack time. The studies were conducted mostly in the afternoon, with a couple of them during mid-morning.

Two researchers visited participants together: while one researcher was setting up the stamp plate, the other was making the food ready on the table, and explained to participants that they could take however much they like, and whatever they like and put them on the screen. The researchers then activated the stamp plate before they started putting the food on the plate. During the eating time, the researchers asked a few questions but mostly let the parents and children interact on their own. The researchers activated the “All Done” button after the participants declared they were all done for them to enter “data play”. In addition to using the stamp plate, each family also completed a separate set of activities as part of a second study outside the scope of this investigation. This data is not analyzed here. As a thank-you for their participation, each family received one digital gift card to Amazon for US\$40.

6.2.3 *Data Analysis*

The research team transcribed field observations from all fourteen families, including their eating behavior with the prototype and their interactions with each other. Body language and facial expressions are also recorded in the transcriptions. I conducted open coding to identify initial themes in the data set, such as data behavior relevance, parents’ guidance, playfulness, as well as relevant theoretical frameworks reviewed earlier. Then I went deeper into the themes and discussed as a group what to focus on to create subsets of relevant themes. I then conducted directed coding to identify occurrences of each theme in each subset of the data. In this process, I realized the theme parents’ guidance is the biggest subset of instances in the fieldnotes, so I went on to develop a detailed codebook. This codebook includes code about data concepts (food & stamp, stamp & behavior, learning how to count, simple math), attention direction, eating guidance, appropriation and eating playfulness. The research team iterated multiple times to settle on the final codes and discuss instances that are not clear to strengthen the codebook. Each researcher

coded a randomly selected subset of the data, and another researcher took the second round of coding and the research team discussed each instance when two coders do not agree with each other.

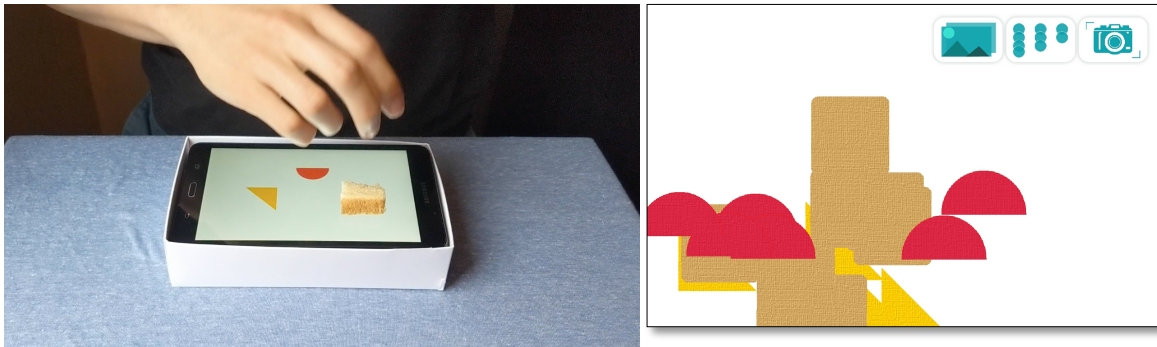


Figure 6.3. Left: participants eating from the stamp plate; right: P12 trying to build a house in “Data Play”

6.3 FINDINGS

In this section, I break down my findings to four themes: food preference, learning data concept, playful interaction and family interaction. I describe how children changed their food preferences by using the stamps to a preferable aspiration of adult’s by eating more food and tried food that they did not want to at the start. I later detail how children are involved in learning data with their parents using the stamps. Further, I present how parents and children involve in playful interaction with the digital artefacts.

6.3.1 *Food Preferences*

We found children’s eating behavior changes over the course of using the stamp plate. Some children displayed food preferences when they first encountered the three food items I brought to the field study. They either said they were not going to have a piece of bread or that they liked apple the best. But their preferences changed through the course of eating and interacting with the

stamp plate. For example, P1 did not want to eat bread before using the stamp plate. Her mother tried to put a couple of bread pieces on her plate, but she refused them by putting the bread back to the bread container. However, after eating with the plate, she asked for more bread because she wanted more brown squares to work with her art. P7 also asked to eat more bread once he realized he could build things by the stamps he generated from eating. He was using the brown square shapes to build a wall across the screen. Once he realized there would be empty spots, he immediately asked to eat more pieces of bread. He ate a few pieces, went back to check how much he had, and said it was not enough. He then returned to the system's "stamp plate" mode, ate more bread, waited for the squares to appear, and went to "data play" to work on his shapes.

In some cases, children forgot their food preferences once they became engrossed in seeing the stamps popping out from the screen. They were eager to try different food and watch how the stamp plate responded to each food item. They hoped to observe what their parents or siblings were eating and what shapes they generated from eating. In several cases, these observations also directed children's attention to the link between what someone ate and what digital image appeared on the plate.

Table 6.2 shows children's change in food preference over the course of eating with the stamp plate. Of the 19 children in my study, 13 expressed food preferences before they started using the stamp plate; almost all the parents encouraged their children to try a certain food item by making suggestions and parent eating behavior modeling during the field study. It is worth noting that six children who did not respond to their parent's cues of eating suggestion ate the non-preferred food after seeing stamps surfaced from the plate (P1-a, P4, P7, P9-a, P9-b, P13). P7's mother exclaimed: *"Look how much food you're eating!"*.

Four children said they wanted to eat a specific food item in order to create a specific shape to play with in the “data play” session after they have claimed that they were done with eating.

In a previous study, I identified through participant observation that one of parents’ major challenges is getting children to eat at a particular time and place[12]. I observed the stamp plate subtly encourage children to eat using features for which I did not specifically design. Echoing the examples illustrated earlier in the session, P4’s mother asked if she wanted to try some bread, but she refused. Her mother asked her a couple of times later and she stopped responding to her. But after seeing the stamps surfacing, she was eager to eat all the food provided in order to trigger stamps to show up on her plate. P4’s mother told us that her daughter does not like to be persuaded to eat anything, but the stamp plate encouraged her do so without any hassle.

Table 6.2. Eating encouragement from parents and the technology

Children	Age	Food preference before trying the plate	Ate food after parent's encouragement	Ate more food after seeing the stamps	Asking more food because of wanting more shapes in “data play”
P1 - a	5	Yes	No	Yes	Yes
P1 - b	2.5	Yes	Yes	Yes	No
P2 - a	4.5	No	Yes	No	No
P2 - b	3	Yes	Yes	No	No
P3 - a	6	Yes	Yes	Yes	No
P3 - b	3	Yes	Yes	No	No
P4	4	Yes	No	Yes	Yes
P5	3	No	Yes	Yes	No
P6	4.5	Yes	No	No	No
P7	4	No	No	Yes	No
P8 - a	5	No	N/a	No	No

P8 - b	4	Yes	Yes	Yes	No
P9 - a	5	No	No	Yes	No
P9 - b	7	Yes	No	Yes	No
P10	4.5	No	Yes	Yes	Yes
P11	4	Yes	Yes	Yes	Yes
P12	3.5	Yes	Yes	No	No
P13	4	Yes	No	Yes	No
P14	6	Yes	N/a	No	No

6.3.2 Parents' Eating Guidance

While eating with the stamp plate, parents often provided guidance for children's eating, and most of these guidelines involved parents prompting children to eat and telling children when they thought the children should stop. Parents often began by asking children about their intention to eat: "*What do you want to eat?*" [P6]). They typically then followed this inquiry with questions about food preferences: "*What's your favorite so far? Cheese, apple or bread?*" [P1], "*Do you want any cheese or bread?*" [P8] or go through each food asking if the children wanted to eat it ([P13]). Parents helped children put the food on their plates while making sure there was a moderate amount of food—enough to eat a substantive snack but not so much that the children wouldn't finish [p10, p12]. Furthermore, parents often directed children's attention to certain food and asked them to eat it. One [P8] parent first asked the children "How many cheeses do you have on them?" while the children started to count, the parent then said, "Can you pick one and put it in your mouth?" She asked because she saw the child was moving the food around instead of eating it. On the other hand, some children showed a strong interest in eating, seeking attention from their

parents as they proceeded to take bites. Their parents confirmed with words like: “*Yeah. You can eat anything on your plate.*”(P8), and “*You want all of them? Okay, go!*” (P5).

When children appeared reluctant to try certain foods, their parents often talked about food not on the table in order to prompt them to eat. For example, a parent [P7] brought up a previous picnic experience at which they had the same food. After eating for a while, parents also asked if the children wanted to eat more food, saying something like “*Do you want more bread?*”[P1], “*Do you want more bread? Apple? Don’t rush. Put it on the plate slowly.* [P3], or “*Can you take a few more!*”[P9] to see if they still want to eat. Children sometimes seemed reluctant to eat, even outright rejecting the food by putting the food from the plate back into the bag [P1]. Parents also played an important role in guiding the children to stop eating. When they notice children are done eating, they would ask questions such as “*You wanna stop eating?*” [P1] or “*Are you all done?*” [P5] and then move on to other activities.

6.3.3 *Understanding Data with Parents*

Parents used a series of questions to link their children's eating behavior to the stamps. They did this in several ways: first, directing their attention to the stamps, then asking the children what the stamps are, and then counting the stamps and doing simple math concepts together. Children came to make sense of the stamps as forms of “data” while engaging in meaningful interactions with their parents.

Directing children’s attention.

Most children in my study did not notice stamps on the plate when they first started eating, but parents discovered them almost immediately. They directed their children’s attention to the plate by exclaiming and asking questions like “oh look what it is on your plate?” and “what is this? You’ve got a half circle!”. They also modeled eating behavior by showing how the stamp plate

worked to the children: *“Yummy, I will try an Apple and see what happens....oh look! a shape came up!”* These questions and actions triggered children to look at their plate, and sometimes their parents’ plate as well. In response, children often took a bite and watched for what might happen on the screen.

Stamp and Behavior Relevance

Stamps and food relationship: If the children were still confused about how the shape comes out after parents directed their attention toward it, parents proceeded to ask more questions about the relationship between a food item and a shape. One parent looked at her child and exclaimed: *“What’s this? You’ve got a half circle!”* The child (6-year-old) looked down at the plate and shouted in response, *“It became a triangle! It’s my cheese!”* The parent smiled and looked at the child, *“Is triangle your cheese?”* [P3].

At another point a child took an apple piece and placed it in his hand. His parent pointed at the child’s screen and asked, *“Like the apple...??? Red pieces.”* The child looked at his screen and ate the food while his parent inquired into the stamps. *“Do you see any cheese pieces?”* she asked. The child said nothing. He nodded his head a bit, took up a piece of cheese with his right hand. *“Do you see any cheese pieces?”* the parent prompted again [P5].

In the above setting, the parent sought to help her child to match the food items with the stamps that were already generated on the plate. When the child took out an apple piece, his parent explained that the red semi-circle represented an apple slice. But the child did not get it. She kept trying: asking another question, pointing to the screen, asking her child to identify a cheese piece on the stamp plate. But instead of pointing out the yellow triangle on the screen, the child picked up a real cheese piece. This action indicated that child did not grasp the relationship between the food and the stamps. Yet when the parent kept repeating the questions while they both were eating

with the stamp plates, the child started to figure out the stamp's relevance and began to call a semi-circle an apple.

When prompted with the “data play” session after they were done eating, children encountered three shapes: triangles, semi-circles, and squares. The system organized the shapes into three lines, resembling line graphs. Upon seeing the lined-up shapes, children seemed to lose the connection between the representational imagery and the food they had eaten. Even when they have made connections between the food and stamps earlier while they were eating, the children interpreted the imagery as arbitrary shapes. For example, P4's parent asked the child what the lined shapes were, and the child answered “*shapes!*”. Children tended not to immediately understand the relationship between their eating behavior and the stamps.

However, children often made complex connections between the representational imagery after prompting from parents. Several parents asked their children to count particular food items. To understand how, consider the following exchange from P1:

“Hey [child's name], how many cheeses did you eat?” the parent asked her child and pointed at his plate.

“Um... I don't want cheese,” said the child responded.

“Ah, you don't want the cheese. How many did you eat? You know how many cheeses you ate?” said parent persisted.

“Um...” the child looked down at his screen and then looked up, “nothing!”

“Nothing?” the parent repeated.

“Mommy brown! Mommy brown!!!” shouted the boy as he pointed at his plate.

From this excerpt I can see how a parent unsuccessfully tried helping her child understand the relationship between the stamp and his eating behavior by asking “how many cheeses” he ate. The

child did not comprehend initially what his mother was asking, but the parent continued to try by telling him she saw two, without telling him which shape the cheese was. To see how this situation began to change, observe how the same parent continued to prompt with questions, even involving the child's older five-year old sibling.

"How many cheese did you eat, buddy?" the parent asked again, "I see two."

The child and his older sibling both looked at his plate. "I see..." the child said, looking closer at the plate.

The older sibling pointed at the brown rectangles and counted by pointed and whispered numbers from one to eight. After she counted to eight, she turned to her parent and said, "I see eight."

"I see..." shouted the child as he looked up at the parent and looked closely at his plate again. "I see... Eight." said the child.

"Breads?" asked the parent.

"Yeah!" the child nodded his head gently, "Breads!"

"Can you count the apples?" asked the parent.

"Okay! count the apples!" said the child. He pointed on the screen to count the red half circles. "Five!" he said.

"I see four," the parent corrected.

"I see four too!" the older sibling affirmed. The group repeated the counting again.

"What about the cheese?" the sibling prompted.

"One, two, three," the child responded, pointing at the screen and counting quickly.

"What about the cheese?" the girl repeated.

The boy counted and pressed the screen (on the yellow stamps) harder, "One, two." ...PI

The above excerpts illustrate engagements I saw repeated throughout the study. Parents tended to require patience and persistence while prompting their child to make connections in order to see meaningful change in their children's comprehension of the representational imagery. The parent depicted above continued to ask questions about the stamps and her child's eating behavior even after several failed attempts. With her five-year-old daughter's help, the boy gradually came to understand both the relationship between the food and the stamps and the relationship between the stamps and what he had eaten.

To cement this latter relationship for children, parents often asked "What did you eat?" I observed parents use this question to help their children understand why certain shapes of food appeared on the stamp plate. For instance, when a child discovered a stamp, P3's parent reacted: "Hmmm!" Her child pointed at his stamp, looking at his parent. "*Wow! You got one! You got a triangle!*" the parent called out. "What did you eat, [boy's name]?" asked the parent (P3). Other parents asked questions like, "*How did you get the shapes? Where they come from?*"(P8), "Why did the shapes come up? What is it? Do you know?" (P9), "What is this square you just ate?"(P3), and "How did you make the stamp appear?" (P7). Parents also repeated similar questions several times. The questions tended to serve a dual purpose: they indicated a relationship between the food and the stamp representational imagery and they prompted their children to figure out how that imagery came to be.

Once children figured out that their eating activity triggered the stamps to appear, they often expressed excitement. For example, P4 screamed with a high pitch and opened her eyes wide. P7 joined her parents in celebrating. The moment she discovered that the stamp imagery was visible in the spot she just took an apple, she raised her arms in the air and began waving them wildly. The waving turned to clapping as her parents chimed in: "*There it is... Yyyyyyyyy!*" Linking their

eating behavior with stamps on the plate, children delighted in the experience and shared this enjoyment among their family members.

6.3.4 *Learning Simple Math*

During the process of eating, parents prompted children to do simple math by asking them to count the stamps on the screen. Such counting happened on either the parent's plate or the children's plate and was not only initiated by parents, but also by children. When parents prompted the children to count, they often asked them to count a specific type of stamp. For example, parents would say things like *"So now mom has a yellow triangle, and yours has how many?" (P13)* which referred to yellow stamps specifically. Referring to the specific type of stamp became a means for parents to examine their children's understanding of its relevance—that is, whether they understood the imagery represented food the child had eaten. In one case, after counting the number of stamps, parents asked their child: *"Because what did you eat?" (P3)* to see if the child understood the relationship between the stamps and the food pieces. Parents would sometimes provide hints using the visual feature of stamps, such as *"Colors...colors..." (P1)*, if children didn't explicitly demonstrate such understanding. Counting appeared to be an engaging activity, which could also serve as a way for parents to make the children concentrate. In one instance, the system crashed after a child tried to count the stamps on their screen (*P10*). The child's parents immediately pushed their plate to the child and asked her to count the stamps on it.

Children appeared fully engaged while counting the stamps. Some children initiated the counting on their own. They demonstrated such autonomy especially when they showed evidence of understanding the connection between the stamp's representational imagery and the food they had eaten. For example, after counting the bread stamps, *P5* asked, *"How come that's twelve?"* when the number didn't align with his knowledge of food pieces eaten. In addition to counting the

number of stamps they had, children also engaged in comparing the number of their stamps with their parents. Children would say things like, “*You count!*” (C7), “*So how much did you eat mommy?*” (C11) in order to prompt their parents to count. They would also count their own stamps and compare with their parents. Children sometimes interpreted such comparison as an invitation for two children to compete (“*so we’re into a competition.*” (C9)) and parents (“*Yeah, you got all of them and I got none. [Mina turns back to mom and makes a “3” hand gesture] That means you win I think.*” (P13)). During such exchanges, children demonstrated full engagement in the counting activity.

The parents in the study seem to take care in structuring and guiding their children’s understanding of the stamp representations. As a form of data, the stamp created a relationship between children’s eating behavior and resulting representational imagery. Parents not only guided children through counting and simple math questions while they were eating together, they also prompted short conversations about the resulting imagery as forms of artwork. These prompts included praising the children, asking what they were making, and laughing together. Some parents are engaged in their own data art along with their children.

6.3.5 *Playing with Stamp Plate*

Beyond counting and math, children enjoyed playing with the stamp plate in imaginative ways, displaying playful expressions and gestures. For example, while using the stamp plate children often used repetitive gestures to interact with the system. One child (P13) actively moved her shape in a circle before turning to her parent’s plate and moving each of the stamps from the left side of the plate to the right side. Next, she moved the stamps one by one to the left bottom corner of the plate while making an abstract sound. In another session, a child (P12) was focusing on moving

all the shapes out of the screen while ignoring all the questions such as “*you don’t like the shapes?*” and “*can you count them?*”

Children were often so focused on their interactions with the plate that they did not respond to their parents. One of the most common unexpected gestures that children did was dragging the stamps to the edge of the screen, as if they were tossing them away. Children drag the stamps either in different directions (e.g. in circle or in line) or outside of the screen.

We also saw children experimenting with different gestures such as erasing the stamps (P4) and swiping. In P5, the child first poked their drawing quickly a few times and made it disappear. They then tried to perform a sweeping gesture from top to bottom several times to drag the stamps out from the corner. The child then dragged the stamp to another corner and stuck out their tongue. Not only did children attempt different interactions with the stamps, they also did it with the food pieces placed on the stamp plate. In one example, the child moved all of the foods on her plate and tried to rearrange them, making the stamps a face.

In addition, I observed children over three years in age spontaneously engage in categorizing and matching activities without parents’ guidance. For example, when a four-year old noticed differently shaped stamps on the screen, the child picked out the semi-circle red shapes and dragged them to the left side of the screen. Another child (P11) tried to match the food with stamps during data play. She picked up a piece of the bread and put it at the location where the brown square stamp appeared.

Children also engaged with the plate in ways that their parents considered “wrong.” One child used a pen on the table to punch the screen as a way to explore interaction techniques with the plate, until her parent stopped her (P13). Another child pressed the screenshot button many times in quick succession. After seeing the screen freeze and then resume, they smiled and said, “Good.”

During another session (P12), the child rapidly touched the screen and scrolled through the whole screen. The parent tried to slow down the child, asking "*Why did the shapes come up? What is it? Do you know?*" But the child did not reply and continued scrolling. In another example, a child used a piece of cheese to press the screen multiple times from left to right. His parent then pulled the child's wrist and made him put the cheese on the left side of the screen.

Children often made sense of their gestures and the stamps on the plate by telling their own stories. These stories often accompanied the gestures and demonstrated the imagination of the children. For example, in P2, the child moved all the stamps out of the screen. After their parents asked, the child said "They're going to the airport!". In P3, A child made a frisbee using the stamp, then described a story about throwing the frisbee on the stamp plate: "*The frisbee is here, when you throw, it will 'bang'!*". In P9, the children referred to data play as "*Like Minecraft...*" and described the stamps they moved on the screen as objects in the game. Parent asked the child "What are you making?", the child replied with "*Cloud...and Imma make a tree! (...) oppsy, this tree is super tall it goes into the cloud. See, the tree goes past the cloud!*" as they were moving the stamps around. In P11, the child first described the process of stacking up the stamps as "building a house". They then switched to "building a rocket" after seeing their parent tried to do it. The child mentioned "*This rocket is mommy's. So I need two of these, So let's bring two of these blocks..*" and started focusing on moving the stamps to try making their rocket identical to their parents'. P12 showed the child first tried to make something on the plate using the food pieces. The parent asked "You're gonna make a face?" and the child responded with a smile. After finished setting up the food pieces, the child mentioned the pattern of food pieces: "*That looks like a robot!*".

6.4 DISCUSSIONS

6.4.1 *Learning Through Routines*

Building on Pappert's core idea of constructivism, "learning through making," our study provides an opportunity for children to learn data concept/mathematics through their routines[95]. Children are already learning many things at mealtimes: healthy eating habits, conversational exchange, table manners, and more. In this study, the stamp plate opens up further learning opportunities that design does not diminish the above but adds another learning opportunity for intrinsic parent-children interaction. We have seen the stamp plate facilitate eating more food and family conversation, as well as an opportunity to learn data concepts. This study shows how learning contexts are created through everyday life routine such as mealtimes among family members.

Children create and build understandings of the world, test it with the context around them, interact with the world, experiment with people around them and adjust their understandings. The "learning through making" idea is that children do not passively intake knowledge, but learn it by doing and through hands-on activities. The stamp plate activities allow children to build and interact with their eating behavior, which is their everyday routine. It takes the "doing" part of knowledge-building back to their everyday life without creating a specific environment and context to learn or do. It augments what they are already regularly doing, mealtime, and weaves in technology objects as a medium of expression which supports self-learning and informal learning with their parents. Rather than assuming learning only occurs in a fixed location, such as a preset space or a bounded time, "learning through routines" flows across locations and time and breaks the boundary between classrooms and homes as learning contexts. Eating can happen in many locations. children eat at schools, at homes, at restaurants, at friends' house, on the cars and in the

parks. Where they are and what the environment is does not prevent them from eating, and they are experts of this routine because it happens multiple times a day. Learning does not have to be limited at a fixed location, provided contexts, or instructions.

6.4.2 *Designing for Meaningful Experience for Parent-Child Engagement*

Designing for meaningful technology use involves attending to the role technology plays in enacting and maintaining valued relationships in everyday life. Within recent Ubicomp and interaction design literature, this concept has underpinned discussions of hedonic and eudaimonia pleasure. Mekler and Hornbæk defines hedonia as about momentary pleasures such as personal achievement and other positive effects[83]. In contrast, they suggest cultivating eudaimonia, which they define as a sense of fulfillment, long-term importance, and feelings of meaningfulness. Applying this concept to design, Lukoff et al. call for designers to support users' sense of autonomy and control in order to support meaning-making while using technology[78]. Takeuchi & Stevens[121] similarly advocate for designing experiences that promote "boundary crossing," which they define as "more than just isolated, one-time events" that "are stimulated and informed by partners' past experiences..." Designing for eudaimonia means highlighting meaningful and lasting experiences of pleasure. As we saw with the stamp plate, these experiences can come from a range of activities, whether togetherness, bonding, play, exploration, learning, or work.

In the deployment of the stamp plate, parents and children engaged in mealtime activities with and through the stamp plate in excess of what parents expected or hoped to experience at mealtimes. Beyond nudging their children to eat more or helping cultivate healthy eating habits and conversations, the stamp plate prompted parents and children to bond with each other by counting stamps together, create artistic renderings with the stamp shapes, laugh with each other by commenting on what the stamp plate displayed. The stamp plate also created learning opportunities

for children around numeracy and single math skills that were likely also learning in their classrooms, extending their formal learning experiences to home settings with their parents. Plowman et. al shows that young children pick up a wide range of competencies at home by interacting with technology guided by their parents, and find that the competencies are the result of parents' engagement with them and technological artifacts[5]. The stamp plate study suggests the need for not only direct instruction or teaching, but also the ability for children to develop knowledge about the world through the interplay between technology design and parent-child interaction in the routine activities of daily life such as eating. In these moments, the stamp plate shows how technology might support the co-creation of eudemonic experiences that become fulfilling through experiences of togetherness.

Chapter 7. DISCUSSION

The studies conducted for this dissertation investigated how to design technologies for young children for their mundane activities, using mealtime as an investigation point. Toward that end, it utilized a theoretical construct from social science through ethnographic-inspired methods, such as observation and interviews, with technology design methods, including human-centered design and speculative design [27], and a field study. Statistical analysis of the surveys was used to complement the mix-methods approach. First, knowledge about the different values that children and parents have in relation to their shared mealtimes was obtained through observations at preschools and in their homes. To further gain the parents' perspectives on technology at mealtimes, given that it is socially and culturally viewed as not a good parenting practice to use technology at mealtimes with children, a speculative design survey was deployed for parents. From these informative insights, three initial prototypes were designed for children to use in lab settings in response to the identified value tensions. One of the designs, the stamp plate, was based on the fruitful results of the laboratory study, and a more fully-functional prototype was built and deployed in a field study for parents and children to use at mealtimes. This updated prototype was used to investigate how children and parents interact using a digital artefact. These approaches help reveal how social conditions and human values are co-shaping digital artifacts, and how technology design might enhance those mutually-shaping relationships.

This dissertation investigates how children's technology use at home emerges as an ongoing engagement with their life routines with the people around them, and how designing for this process of engagement can lead to creativity and meaning-making experiences. It is hoped the design outcomes and insights can be expanded to the everyday integration of smart objects into

family life for children. This chapter discusses the dissertation's research questions and how the data from the studies answer those questions.

7.1 TECHNOLOGY FOR FAMILY ROUTINES

The four investigations conducted for this dissertation aim to expand the possibility of designing technology for children in their daily routines and mundane activities, such as mealtimes. Specifically, technology can be designed to support children's exploration and creativity in the actions of completing a mundane task, and not for the purpose of the task itself. As noted in Chapter 3, when the children were observed during mealtimes, they engaged in multiple ways of eating their food beyond the adults' "normal" ways of eating. Specifically, to design the proposed technology, the ways in which children eat and play with their food were explored. As noted in Chapter 5 and Chapter 6, with a smart object presented at their mealtimes, the children organically started to track their eating behavior, explore plating with the food stamps, engage in intimate interactions, and start learning data concepts with their parents.

More significantly, the values that the parents care about, such as eating more food, trying new food items, and participating in family conversations, were not sacrificed with the new possibilities the digital devices had created. The pleasantly surprising results are not because the stamp plate aimed to help children learn, or make a playful application for them, but because the artifact specifically seeks to augment what children are already doing. As Lucy Suchman notes, technology design should be "artful integration" [119]. According to Suchman:

New ways of working and new technologies grow out of old ones. They do so neither through a process of simple incremental change, nor through wholesale displacement and transformation,

but out of an ongoing interaction between understandings based in prior experience on the one hand, and leaps of faith inspired by imagination on the other [119].

The stamp plate explores the ways in which a connected device is embedded in the situational existence of what families are already doing; this gives the digital object a sense of imagination, which is turning what the users eat into stamps on the stamp plate screen.

A body of HCI work in Ubiquitous Computing and design research has long been developing the concept of “slow technology”, prompting technology design to inter-react with the environment, with the goals of supporting reflection, reminiscence, joy, etc. [51,91,92,109]. There are also calls to reject the typical utilitarian and effective design goals for smart homes, and encourage designers to design for the lived-in experience [21]. The present work further contributes to this body of literature and encourages designers to design digital artefacts for what families have already been using, not to impose an external goal on the design. Families already have their own goals, which is to be “in the moment”. Designers can design for internal positivity, instead of extrinsic satisfaction.

7.2 DESIGNING TO SUPPORT CHILDREN’S PLAYFULNESS

There is a body of design work around the digital augmentation of young children’s mealtimes and the artefacts within them (e.g., [63]). A particular emphasis has been on parents’ goals and aspirations for their shared meals. In contrast, children’s intrinsic motivations, their desires for autonomy, comfort, and play, have largely been neglected. Often the approach has been to add some playful features, such as sound, to draw children’s attention. Other than this, children’s desires at meal tables have received little attention. Although parents exercise power in parent-

child relationship [1], it does not mean technology for children that is being used in their everyday lives must only meet the adults' goals, nor does it only have a utilitarian goal.

In “Lifelong Kindergarten: Cultivating Creativity through Projects, Passion, Peers, and Play” [106], Michel Resnick distinguishes creative toys from toys that help children become creative. The difference is that, for creative toys, the creativity applies to the efforts of the designers and the engineers who design the toys, not the children who play with them. In contrast, toys that help children think are a supportive tool for their creative exploration. In the analytical processes presented in this dissertation, two of the prototypes, the cat fork and the kicking chair, garnered positive responses from both adults and children, but concerns from adults about redirecting the children's attention from the current context (in this case: eating) also surfaced. These two prototypes are illustrations of creativity in the design, but they fail to support children in building, exploring, and experimenting with them. They are fun, but they do not help a child to playfully engage in the world. However, the opposite is true for the stamp plate. By identifying what is meaningful in the context of children eating their food in playful ways, the stamp plate supports their existing and emerging playful initiatives, and it uncovers opportunities for meaningful engagements in the mealtime contexts. The smart object designed for children did not “invent” new things for children to explore; rather, it enhanced the observed, preexisting playful activity and attitudes that children already possess.

7.3 INDEPENDENCE AND TOGETHERNESS

One of the greatest challenges of designing shared media experiences to engage both parents and children is that there is only one screen, and when they share one screen, the content is usually designed for children. Existing theories and frameworks, such as value-sensitive design, which

supports values for all stakeholders [39], and Joint Media Engagement (JME), which is a framework created specifically to support meaningful interactions between parents and their child [121], have already addressed the issue of loneliness and separation with technology use. The stamp plate further contributes to this by creating an artefact that embodies being independent with a sense of belonging and connection in family lives.

The stamp plate is a personal device that fosters a sense of autonomy and pride. Present at every step of the process, the user's eating behavior is the creator of what surfaces on the plate. Each step requires the participants to be involved in the activity, and it requires an action before the results are seen. Because users control the production of the stamps, they experience a sense of ownership and pride that emerges from their involvement in the activity of eating. Children expressed a sense of pride when they counted their stamps and learned they have more than their family members. The stamp plate also creates an enjoyable personal experience by enabling users to create their own artwork.

Moreover, the stamp plate facilitates the potential for family members to interact at the meal table. Families create meaningful experiences with their loved ones by learning simple math skills together, counting the shapes, looking at each other's creations of the stamp artwork, and commenting on how beautiful they are. The shapes that the stamp plate produce also engender discussion and interactions. The moments when users are making sense of shapes as they are eating together create opportunities for fruitful interactions at the meal table, such as learning, intimacy, and playfulness.

What makes the stamp plate engaging is that it is versatile and easy-to-use, and it promotes playfulness. As observed in the field study, it is a simple, digitally-connected plate that does not require a sophisticated understanding of the device before users can begin to use it. After the users

are done eating, the stamp plate invites them to move the stamps around, and the users automatically start to make their own creations. It is versatile in the sense that it is a functional plate that encourages children to eat more and a digital artefact that encourages family members to become involved in novel and creative interactions. Playfulness emerges in these interactions, both while eating and when manipulating the shapes afterwards.

Imagine a chilly Sunday morning at home. All the family members are in one shared space. The parents are reading, cooking, or doing their chores, while the children are involved in their playful activities. They are all doing their own things, but they will also interact with each other, because they are in the same space. How might a device be designed for this ordinary scene to support the children's sense of relationship and connectedness without diminishing their autonomy and independence?

It is important to envision technologies that can support meaningful interactions in the daily routine of family life instead of separating people from each other or partially favoring a certain stakeholder in a heterogeneous user group. The design should enable and favor the dynamics of the situational existence of home. Thus, this dissertation proposes a framework composed of five different dimensions to help people experience their daily life routine together:

- Offer the opportunity for each family member to exercise his/her own values;
- Foster a sense of autonomy and independence;
- Favor rich social interactions between users;
- Allow playful explorations for the engaged activity;
- Augment the existing behavior and add imagination for creative explorations.

These are preliminary categories, but, hopefully, they can serve as a potential framework for technology design that augments daily behavior and fosters family members' desire to connect

with each other. According to a longitudinal study at Harvard [38], researchers have found a strong association between happiness and close relationships with spouses, family members, and friends. How can technology be designed to help people tend their relationships with family members and augment their behavior?

This preliminary framework may help facilitate the ability to design digital objects that address the user's relationships at home. It results from the current study's investigation into family mealtimes with young children, but it can be extended to other family routines, and it will contribute to a broader view of how designers can create technology that fosters a meaningful relationship between parents and their children.

7.4 CONTRIBUTIONS

The first contribution of this work is empirical. The studies presented provide detailed examples of how young children and their parents express and enact their unique values within their family routine, using mealtime as an investigation point. This work describes how heterogeneous family members reacted to and interacted with a connected set of everyday objects at their shared mealtimes: forks, plates, and chairs.

The second contribution is the design processes for creating mealtime technology for children. The participant observation method was used to observe children's mealtimes with their caretakers, utilizing the interaction they had with the food presented to them. Because it is difficult to interview preschoolers due to their developmental age, their interactions with their food were observed, and ways to augment this interaction were considered. In this stage of the study, how the adults' values also manifested in their behaviors were also observed. By pursuing the playfulness inherent in the nature of children while keeping in mind the values of parents, it is

possible to provide the research community with ideas on how to design for these different perspectives by uncovering and acknowledging the shared experience they are creating in action.

The third contribution of this work is the digital artifact that was created: the stamp plate. By embedding the values of different family members, the stamp plate was demonstrated to be capable of engendering rich and meaningful interactions at mealtimes. The artifact contributes to the HCI community as an example of an everyday object, which is already part of ordinary life routines, that, when connected, can address the tensions created by the already-present, differing goals of children and adults. This changed the current lens of smart objects that are being used at home to serve a specific goal and specific user groups.

The fourth contribution is theoretical. A framework was created to examine and include the values of both adults and children in the design. The design outcomes and insights generated in this dissertation can be expanded to inform the everyday integration of smart objects into the family lives of children by considering family lives holistically. Designers who design emergent technology for family routines can consider the complexity of the relationship between technology and the routines of family life by foregrounding their potentials to foster meaningful engagement and creativity.

7.5 FUTURE WORK

What designing for meaningful experience may look like was outlined in the stamp plate study; however, this is limited to what was observed with one specific family routine (mealtimes). A logical next step of the research will be to generate a concept of meaningful experience in family lives and determine what it means to design connected objects for a meaningful experience at home. It will be worthwhile to strengthen and expand the typology and framework of what it means to

design for meaningful experiences for preschoolers. The outcome of the stamp plate study suggests that a further area of investigation might be the data practices and data literacy between young children and their family members, including their parents and siblings. Several questions should be considered. How do children decide, make sense, present, discuss, and learn about data concepts in their everyday lives with the people around them? What interactions emerge with the data and their family? This is a rich and fascinating research agenda, and an obvious next step in this research process.

Exploring family lives and their perspectives on technology in different geographical locations and cultures is another obvious next step for this research. The observations and interviews conducted for this dissertation were done in a single metro area in the United States (US), and the survey study was deployed in English, with respondents who are all currently living in the US. Thus, the mealtime practices investigated in this dissertation, and how children and their families react to technologies, are all US-specific. Moreover, the notion of “family” presented in this dissertation is steeped in middle-class American ideology. There are different family compositions and types of family interactions that were not addressed in this dissertation. For example, in some cultures, it is common for young children to share mealtimes with extended family members or their neighbors, or for them to be seated at a separate table and not to be allowed to eat with adults. To compliment the US-centric focus of this dissertation’s investigation, future research will investigate family mealtime practices, technology adoption barriers, and parents’ perspectives on screen time in other cultures. Doing so will yield fruitful insights for the HCI community about designing technologies for families.

Furthermore, the survey and laboratory study were conducted with a small group of people, and the stamp plate was given to the users for a short period of time. Although behaviors were observed

in these initial sessions that parents said were atypical, and the children were all engaged, it was not possible to know if the novelty would quickly wear off, or conversely, if such a tool might become a problematic crutch in the long-term. In the future, the goal is to study the relationships that children form with these prototypes over time, especially for objects at home that are meant to be used for a long time.

7.6 CONCLUSION

Smart speakers, like Alexa and Google Home, are the fastest growing consumer products in the US and the rest of the world [134]. Moreover, with 5G internet, it is predicted that everything in a household, from an oven to an ordinary bowl, will be digitally connected. While the idea is that technology can help homes become more efficient and orderly, fewer studies have investigated how these connected everyday objects are going to influence those who live with them, and how families configure these technologies with their lives. Another crucial problem is how adults, as parents or specialists, define the time children spend with these devices. Does interacting with a smart speaker count as screen time? How about using a smart backpack to plan and reflect on children's school life? What if children spend time with their lunch boxes to determine what they have been eating and plan for their meals? Technology use and non-use should not be a source of burden for parents; neither should it be a guilty pleasure for children. Everyone will have the opportunity to engage with technology at any moment. That is precisely why there is a potential for designers to offer interaction techniques in objects at home for a positive, meaningful, and naturalistic experience, because technology is current and spontaneous.

By understanding how families enact and express values through their daily routines, and by designing and deploying an emerging technology that is also an ordinary artefact in family life,

the results of this study have demonstrated that designing for internal and pre-existing family interactions and supporting their intrinsic motivations is fruitful for generating opportunities for families to create meaningful experiences for themselves. The present study has provided an example of a digital artifact and a preliminary framework for designers to design a future of technologically-embedded homes that support intimate relationships and enrich the life experiences of the people who live in them.

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