Understanding Parents' Perspectives on Mealtime Technology

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For young children, family meals are an enjoyable and developmentally useful part of daily life. Although prior work has shown that ubiquitous computing 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. This paper examines adoption barriers for technology for family meals to understand with more nuance what parents value and resist in this space. Using mixed methods, we first observed family dinnertime experiences and then surveyed 122 parents with children from two to six years old. We found that parents prefer screen-based technology over voice interfaces and smart objects, because parents perceive the latter two systems to intrude on their relationship with children. The pervasiveness of smart objects embedded at meals led parents to worry about distraction and technology dependence, while the anthropomorphization of voice interfaces led parents to worry that this technology could displace parenting relationships or disrupt interpersonal interactions among family members. Parents mindlessly applied social scripts to voice interfaces, suggesting families may be more likely to apply concerns from interpersonal interactions to voice interfaces than to other technologies. We discuss the ways different form factors appeal to and worry parents, providing designers with insights about the likelihood of adoption and acceptance.

CCS Concepts: **Human-centered computing~Empirical studies in HCI** • Human-centered computing~Empirical studies in ubiquitous and mobile computing

Additional Keywords and Phrases: Mealtime, family, parents, children, Internet of things, smart devices, speculative design, conversational agents

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1 INTRODUCTION

Meals are an important part of daily life for young children; they are essential to physical growth and development, and they provide a social space for bonding, learning, and acquiring communal norms. A broad array of literature in numerous fields has documented ways in which decisions related to food choices, meal structure, family togetherness, and other factors can support children in accruing developmental benefits through meals [39]. As a result, a number of prior studies in ubiquitous computing have proposed novel technologies to promote positive mealtime experiences for young children. For example, Lo and colleagues

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created a smart tray that uses digital play to increase children's focus on the meal [37], Kadomura and colleagues developed a digital fork to educate young children about the importance of eating a balanced diet [29], and Ferdous and colleagues demonstrated the potential of mobile devices to enhance family communication and togetherness during meals [14].

Despite the potential for novel technologies to play a useful role at mealtime, other work reports that some families express resistance to technology (writ large) in this context. For example, in an online survey probing mobile phone usage during mealtimes, people reported that they believe it is inappropriate for children to use mobile phones at meals, and further, that it is less appropriate for adults to use mobile phones when children are present [41]. Other work reports that parents and children alike often expect family members to set aside technology during meals [23]. Expert recommendations support this pushback and call for families to treat meals as media-free spaces (e.g., [11,19,28,54]). These recommendations are derived from literature linking adverse outcomes (such as obesity [11,19] and reduced family interaction [54]) to the use—specifically—of screen-based entertainment media at meals. However, this evidence base has been translated into recommendations that do not discriminate by form factor and discourage technology use of any kind at meals.

As a result, we see the potential for ubiquitous computing solutions to support young children's and families' mealtime practices in many ways, but we also see the potential for such solutions to be overlooked or rejected because of larger narratives pushing back against the use of technology in this context. Thus, the purpose of this project was to understand the extent to which such adoption barriers exist in practice by probing parents' reactions to various design scenarios. In doing so, we sought to capture nuances in what families might find valuable and what they might find problematic and to give designers a more precise understanding of families' interests in this space.

To investigate these questions, we took a two-part approach: first, we conducted observations and interviews with eight families to understand their values, goals, and desired practices with respect to family meals, which we used to create a taxonomy of four design opportunities. Second, for each of these four opportunities, we created three storyboards presenting novel design solutions, one for each of the three form factors (for a total of 12 storyboards altogether). 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 we wanted 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, we 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.

Using this formative work, we 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). We found that regardless of the design opportunity it addressed, parents were significantly more accepting of screen-based designs than either of the other two form factors, and significantly more accepting of smart objects than voice interfaces. Separately, regardless of the form factor, parents were significantly more interested in using technology to educate children about making healthy eating choices than to encourage children to eat more or to manage family conversations. Through a content analysis of participants' free-response reactions, we uncovered many of the reasons behind these choices, showing for example, that the familiarity of screens makes them more acceptable, the personification of voice interfaces positions them as intruders in an intimate space, and the physicality of smart objects introduces practical questions of durability and cleanliness. Some goals (such as learning more about healthy foods) were broadly seen as technology-appropriate, while others, like mediating conversation or setting boundaries for children, were seen as the unique provenance of the

human actors involved and off-limits for technology. Across all form factors, we saw responses of interest and disinterest, and we characterize the frequency and content of both perspectives.

The contribution of this work is to provide designers interested in family meals with a more nuanced understanding of how parents might respond to novel design solutions for this space. Further, we discuss how these results might extend to other aspects of family life, as 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.

2 RELATED WORK

2.1 Designing for Human-Food Interaction

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 [42] provide entertainment during meals [42], deliver memorable experiences around food [14], and help people eat healthily [45,47,52]. These diverse investigations leverage augmented reality, screens, smart objects, and other digital tools to enhance or shape users' experiences with food [5].

Most studies exploring this space focus on a problematic aspects of users' relationship with food and attempt to provide correctives [20]. 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 [1]. 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 [34,41,55]. Most notably, Grime and Harper [20] 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 [6,12,13,16]. Ferdous and colleagues designed an application called "TableTalk," which integrates personal devices of people who share a mealtime into a single shared display [14] to make personal content part of a collaborative experience.

Here, we build on this prior work by first continuing a long-standing tradition of close observations of family meals. We do so with an eye toward understanding pain points for families and identifying potential design opportunities. We further expand on this past literature by exploring families' openness toward a variety of technologies, providing empirical data for others who seek to use technology to enhance families' meaning-making processes around meals.

2.2 Designing for Children, Families, and Meals

Separately, 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 [18,27,35,49], particularly connecting with distant family members and communicating within the immediate family [31]. 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 [24], leaving notable gaps in our 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 [8].

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 [32], a smart flatware set that attempts to persuade children to increase their vegetable intake [26], or a pressure-sensing fork and cup to persuade children to eat a balanced diet [30]. 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 [56]. 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 [50].

These studies and others suggest an interest in developing novel technologies for family meals that encourage children to engage in food-related behavior change. Our 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 our 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 Parents' Attitudes 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 [58].

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 [23]. Moser and colleagues document that adults often feel technology at meals is inappropriate and that these feelings are augmented when children are present [41]. 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[40].

Together these studies show decisions around children's technology usage are often fraught for parents. Although families are eager adopters of technology [3], regularly rely on technology to support or resolve domestic challenges [24], and face common struggles around meals [54], 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, we examine parents' reactions to integrating technology supports into meal-time experiences, looking across a diverse set of technology types.

3 PRELIMINARY WORK AND DESIGN PROCESS

As the goal of this work was to understand what technologies for meals might appeal to parents, we conducted a two-part study. First, we performed a qualitative study using in-home observations and interviews to closely examine parents' needs and goals during family meals. Second, we conducted a survey to evaluate how each of the three technology formats (screens, voice interfaces, and smart objects) might support parents in pursuing each of the major goals we identified through our observations. The formative work to identify parents' values and goals as well as the survey's design scenarios are described here.

3.1 Design Methods: A Qualitative Exploration of Family Meals

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

Participants were recruited through family housing email lists and neighborhood parent groups in the greater metropolitan area surrounding our institution. We asked parents who responded to our 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. We chose to interview only one parent to minimize disruption and allow the second parent, if present, to attend to the children. Here, we 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.

We 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 [4], we 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"[57]. Later, we went through iterative rounds of coding and wrote memos to discuss in the research group. We then collaboratively converged on four common themes that reflect parents' most salient concerns in this context.

Table 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 Design Results: Mealtime Goals

Although each family presented unique interests, goals, and interpersonal tensions at meals, we 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.

3.2.1 Healthy Eating Habits. Parents told us 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: "*We 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 we 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 we 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, we saw a girl pick up a food and describe 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, such as adding two eggs to a pancake recipe that calls for one to increase a child's protein intake (P3).

3.2.2 Eating More Food. Conversations about what children eat and how much they eat dominated mealtime interactions during our 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, we 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 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.

3.2.3 Table Manners. Across families, we 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, we 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…we sit for a set amount of time and we 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, we 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.

3.2.4 Mealtime Conversation. Finally, we 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. We 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 our 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. We 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.

4 SURVEY

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

4.1 Survey Design

We first recruited a group of volunteer designers—all current students with a background in design—to help us generate design concepts for the survey. We iteratively brainstormed and refined ideas for each of the 12 different categories (see Table 2). To understand how parents felt about using each of the three different types of technology (screens, voice interfaces, and smart objects), we 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[9,46] that position possible futures as sites for examining technological developments in the present. Drawing from early literary traditions of speculative fiction [e.g. [21]], 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[17] .

Table 2: The specific technologies presented in the 12 user scenario storyboards shown in our 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.

We 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, we 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 we 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. We also included general questions in the survey about families' technology use and attitudes about technology during family meals.

We 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 our survey. We asked parents to reply only if they eat meals together with their child at least twice a week on average. We 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. We 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, we first compared quantitative responses to each technology type and each meal-time goal using SPSS statistical software. We performed a qualitative open coding of parents' text descriptions of their reactions to each storyboard, examining open-ended responses in light of our quantitative results. We 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, we laid out the corresponding affinity diagrams and examined the themes that held across them. Later, we examined each quote and used structured content analysis to determine which themes were more salient across the three forms of technology.

4.2 Survey Results 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, we 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. Our 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 ($F(6, 121) = 3.179$, $p = .004$, $\eta_p^2 = .025$).

We re-ran the repeated measures ANOVA using each of the other acceptance measures we 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 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.

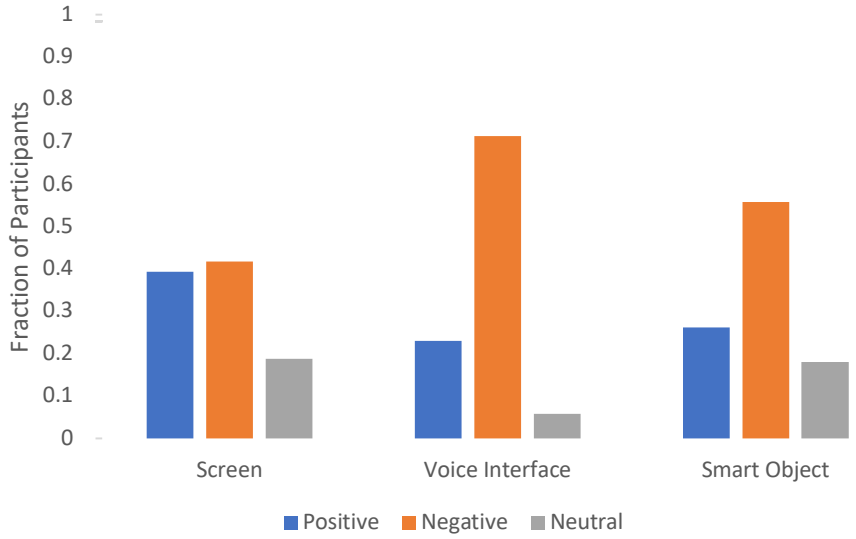

Fig. 1. Fraction of participants who responded, on average, positively, negatively, and neutrally to scenarios for each form factor.

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 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 2 shows the fraction of participants who brought up each concern with each technology, and in the following sections, we describe concerns and adoption barriers with respect to each form factor in participants' own words.

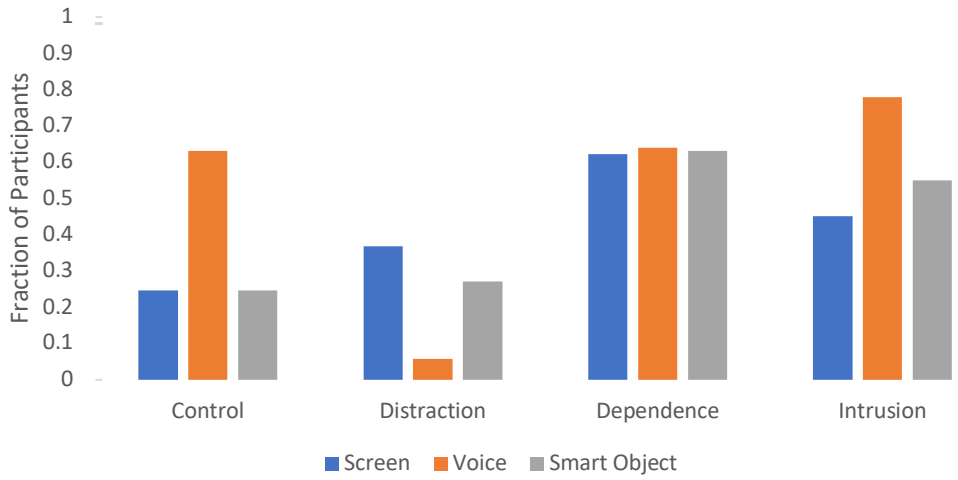

Fig. 2. Fraction of participants who brought up concerns in each of four main categories when responding to storyboards for each type of technology.

Table 3. Descriptions and examples of top-level concerns that parents expressed (each of which had several sub-codes).

	Description	Example
Control	Technology should not encourage or tell children what to do, be in control, make decisions, or direct users.	"I do not like the idea of eating reminders. It builds reliance on technology rather than someone's natural body cues of hunger."
Dependence	Using the proposed design would lead to problematically more technology use.	"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."
Distraction	Any mention about technology being a distraction or pulling family members attention away from something the participant feels is more deserving of that attention.	"However, I am a bit concerned that the buzzing may disrupt an ongoing conversation."
Intrusion	Intrusion, creepiness, or inappropriate presence of technology.	"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?!"

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 our 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 our 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 our 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 our 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 we 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. We saw that the smart object designs we 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 we tested, parents were most accepting of our 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 we do something similar or related: look up videos or pictures of something we are talking about (spaceships, volcanos, etc)*."

Similarly, other parents responded to screen-based storyboards by saying things like, "*we do this sometimes with YouTube already*" or "*we have done a version of this with our children where we introduce them to the Abby broccoli song and sing it together when we eat broccoli.*" Across all four scenarios, parents expressed more familiarity with screens than with the other two form factors we 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. We heard this concern echoed in responses we 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 we 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.*"

5 DISCUSSION

Consistent with prior work, we 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, our 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.

5.1 Dependence and Distraction from Ubiquitous Technology

Despite this variety, all three of the form factors we 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. Our 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 [2,7,44,51,53]. 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 [53]. 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 [44]. 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 [10,36,43]. Thus, parents' concerns about our 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 [44] and that social narratives about technology as distracting and addictive are unhelpful and unfounded [22]. 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 [33].

Our 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, we 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.

5.2 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 we 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 [48]. They examine user reviews from Amazon Echos'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"[38].

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. Our 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 our study as an intrusive other, rather than a useful tool.

5.3 Limitations

Our study provides empirical evidence about three form factors only; end-user-facing technologies today take many forms, and products like wearables, haptics, virtual and augmented reality, and any number of other

experiences might produce very different responses. There are many ways that technologists might aim to shape families' meal-time experiences, and we have not come close to comprehensively mapping this design space. We merely examine reactions to a few common technologies and some of the ways in which they produce differentiated responses from parents.

Separately, the notion of "family" presented in this study comes out of middle-class American ideology. There are different family compositions and forms of family interaction that are not addressed in this proposal. For example, in some cultures, it is common for young children to share mealtimes with extended family members and their neighbors, or for them not to be allowed to eat with adults and have a separate table for them. Our observations were conducted in a single metropolitan area within the United States, and all survey participants were currently living in the United States as well.

We asked parents about technologies that not all of them had tried, and they were necessarily making speculative judgments about interactions with systems they may have never encountered. While we hope these findings capture some aspects of families' relationships with technology, they may be more useful for understanding adoption patterns and suspicion about unfamiliar technologies than for understanding the way families experience the technologies they use in daily life. We are eager to explore the latter in future work.

6 CONCLUSION

Here we present a two-part study comprising empirical research and survey data to understand parents' attitudes toward technology during family mealtime. We used four themes that emerged from our formative qualitative studies to design 12 storyboards depicting three types of technology devices (screen-based, IoT object, and voice interface). We then incorporated the storyboards in a survey with parents of young children. Our 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, we 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 we presented prompted parents to express concerns about becoming more dependent on technology. With this work, we sought to attune designers to parents' perspectives on technology around meals and the likelihood of these systems appealing to this user group. We highlight parents' concerns of technology prompting intrusion, lack of control, dependence, and distraction, themes that we claim will be relevant for family meals, and may also inform the design of experiences for other aspects of family life.

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