"Families are messy": From Parent-Child Tensions to Family-Centered Design of Smart Home Technologies

Kaiwen Sun
Informatics
Indiana University Bloomington
Bloomington, Indiana, USA
School of Information
University of Michigan
Ann Arbor, Michigan, USA
kaiwsun@iu.edu

Jade Xiaoyi Li
The Information School
University of Washington
Seattle, Washington, USA
jadeli@uw.edu

Irene Chung
School of Information and Stamps
School of Art & Design
University of Michigan
Ann Arbor, Michigan, USA
chungpy@umich.edu

Jenny Radesky
Department of Pediatrics
University of Michigan
Ann Arbor, Michigan, USA
jradesky@med.umich.edu

Jason Yip
Information School
University of Washington
Seattle, Washington, USA
jcyip@uw.edu

Christopher Brooks
School of Information
University of Michigan
Ann Arbor, Michigan, USA
brooksch@umich.edu

Florian Schaub
School of Information
University of Michigan
Ann Arbor, Michigan, USA
fschaub@umich.edu

Abstract

Smart home technologies have become common in family homes, making even young children inevitable users of these technologies. However, these systems are typically designed for individual adults, creating family tensions and conflicts over children's access, safety, and appropriate smart home use. To investigate children's and parents' individual and joint smart home needs and dynamics, we conducted an in-home study with nine families (children aged 6-11). We identify four key parent-child tensions with smart home technologies, including struggles over parental protection versus children's autonomy, differing views on technology's purpose, disagreements over technology-enforced routines, and children's vulnerability to embedded commercialism. Our work reconceptualizes parental mediation as a process of "tension management" rather than the application of static rules. This research challenges the dominant individual-centric choice architecture in smart home design, calling for a family-centered approach that acknowledges and adapts to the fluid, complex, and negotiated reality of modern family life.

CCS Concepts

• **Social and professional topics** → **Children**; • **Human-centered computing** → **Empirical studies in ubiquitous and mobile computing**; *Empirical studies in HCI*; • **Security and privacy** → *Social aspects of security and privacy*.

Keywords

Families' use of technologies; parent-child relationship; home; smart homes; Internet of Things; domestic technology.

ACM Reference Format:
Kaiwen Sun, Jade Xiaoyi Li, Irene Chung, Jenny Radesky, Jason Yip, Christopher Brooks, and Florian Schaub. 2026. "Families are messy": From Parent-Child Tensions to Family-Centered Design of Smart Home Technologies. In *Proceedings of the 2026 CHI Conference on Human Factors in Computing Systems (CHI '26), April 13–17, 2026, Barcelona, Spain.* ACM, New York, NY, USA, 21 pages. https://doi.org/10.1145/3772318.3790865

CHI '26, Barcelona, Spain

ACM ISBN 979-8-4007-2278-3/26/04
https://doi.org/10.1145/3772318.3790865

1 Introduction

Growing HCI research has identified that families use various types of smart home technologies [21, 23, 26, 57, 73, 74], such as smart speakers [5, 40], monitoring cameras [29, 30], smart locks [75, 76], and smart lights [9, 11] for different purposes such as convenience [68, 69], learning [18, 34], security [41, 48, 53], and entertainment [32, 33]. While these studies have provided valuable insights into how families integrate smart devices into everyday life, they primarily feature adult perspectives, offering a limited understanding of the children who live with and actively use these systems.

The few studies that have focused on children and teens have typically examined individual smart home devices, such as smart speakers for communication [4, 5, 25], toys for play [22], or cameras for monitoring [65], rather than interconnected smart home systems. This device-specific lens leaves open questions about how

children experience and navigate multi-device interactions, and how parent-child dynamics are shaped by smart home technologies that are embedded in routines and relationships. Addressing this gap requires a child-centered and holistic view of smart homes that considers the interplay of multiple devices and the tensions they create within families [55, 61].

Our study focuses specifically on middle childhood children (6–11 years old), a period when they actively use smart home technologies [59], are more likely to own their own devices, and begin developing basic digital literacy [38, 60]. Children in this age group tend to follow clearly explained rules but may not have a clear understanding of the risks associated with their digital behaviors that are less direct or obvious [38, 46]. This makes them an important group to study to understand how smart home design supports or affects children's growing needs and family relationships.

With this premise, we examine children's lived experiences alongside parents' roles in supporting children's smart home use. As the smart home is a shared space where lives intertwine, we view it not as a collection of individual users, but as a shared family concept [27, 42]. We examine two central questions:

- RQ1: What needs and tensions arise for children and parents regarding children's smart home use?
- RQ2: How could smart home technologies be designed to better support parent-child shared participation while balancing child safety and agency?

To answer these questions, we used an adapted *Mosaic* method to piece together children's perspectives [16, 28]. We combined interviews, child-led home tours, and a self-paced design workbook inspired by existing smart home design research [19–21, 30, 72]. This multi-faceted approach allowed us to capture the rich, contextual experiences of both children and parents.

Our study involved nine families (children aged 6-11) who use smart home technologies. From this work, we make three key contributions:

First, we extend prior device-specific research by offering a deepened and nuanced understanding of parent-child tensions in integrated smart home environments in four aspects: (1) **monitoring as care vs. surveillance**, where parental protection needs conflicted with children's developing autonomy; (2) **utility vs. play**, showing conflicting views on the technologies' purpose and their engagement-driven design; (3) **convenience vs. rigidity**, arising from disagreements over technology-enforced rules and routines; and (4) **education vs. persuasion**, regarding family struggles in responding to devices' embedded commercial agendas.

Second, by revealing these tensions and examining how parents manage and mediate children's smart home access and use, we reconceptualize parental mediation as a dynamic process of **tension management** rather than the application of static rules.

Third, building on families' design ideas and responding to these tensions, we further identified six recommendations for creating domestic IoT technologies that support shared participation and negotiation within families: (i) shifting from individual-user models to systems that support shared experiences; (ii) providing mechanisms to address tensions, negotiation and compromise; (iii) offering controls that adapt to children's development to support responsibility and self-regulation; (iv) avoiding over-engagement and distracting designs; (v) incorporating playful features that facilitate connection; and (vi) involving diverse families in the smart home design process as both ethically necessary and a sign of quality. By centering children's perspectives and introducing holistic smart home design recommendations, we contribute to HCI's broader agenda of creating technologies that support relational dynamics in family life.

2 Background and Related Work

We contextualize our work by engaging with three areas of HCI and childhood studies: existing literature on parent-child tensions about smart home technologies, parental mediation of children's digital technology use, and participatory methods for researching children's lived experiences that have informed our study design.

2.1 Parent-Child Interactions and Tensions Around Smart Home Technologies

Modern family life is intertwined with technologies, influencing children's living [61, 65], learning [24], and play [5], especially when these technologies were not originally designed with children in mind [59]. At the same time, the home environment plays a critical role in children's development of autonomy and competence, fostering a sense of security and trust while facilitating both privacy and social interactions [67].

While early research on domestic IoT focused on functional benefits like convenience and energy saving [31, 58, 69], growing HCI work has recognized the smart home as a site of social interactions [19, 57, 61], negotiations [4, 5], and sometimes a *"battlefield"* for domestic life [42]. However, much of this existing inquiry has examined these tensions through the lens of individual devices. Research on smart speakers, for instance, has extensively documented how voice interfaces disrupt family communication. Beneteau et al. [4, 5] and others [3, 25, 64] revealed how these devices create new forms of conflict, such as children interrupting parents or siblings fighting over command control. Similarly, research on home monitoring systems has highlighted the tensions between protection and privacy. Ur et al. [65] and others [29, 30, 72] demonstrated how smart locks and monitoring cameras can unintentionally create trust issues among families, turning the home into a space of surveillance.

Additionally, while recent work has begun to address multi-user needs like child-friendly interfaces and controls [11, 23, 26], these efforts remain primarily focused on adult users' perspectives. This leaves a gap in understanding children's lived experiences in smart homes and how they navigate integrated smart home systems in which cameras, speakers, lights, and other smart devices are interconnected and operate simultaneously. Our work expands on adult-centered, device-specific findings from prior work by shifting to a child-centered and holistic perspective. This approach enables us to explore design considerations that mediate family tensions, contributing to HCI's broader discourse on designing technologies for shared domestic spaces [21, 30, 52, 57].

2.2 Parental Management and Mediation of Children's Use of Technologies

Parental mediation theory has been the guiding framework for understanding how parents manage their children's media engagement. Originally developed in the context of children's TV watching, early strategies included active (discussion), restrictive (rule-setting), and co-viewing [44]. Over time, the theory expanded as children's media use evolved from using passive screens to more interactive digital modalities to describe how parents manage children's use of technologies concerning online safety [43, 70], privacy [47, 56], and device usage [10, 39]. Clark argued that the digital age required moving beyond simple restriction toward *participatory learning*, where parents and children interact together through digital media to foster agency [17]. Meanwhile, the rise of personal mobile devices led to "authoritative" mediation styles, where parents managed the device's portability through strategies like temporary access, time-limiting and parental control software, or "digital grounding" [8]. However, these evolved strategies still rely on the affordances of personal, screen-based digital technologies owned by individual users.

The emergence of smart home technologies poses different challenges as the interactions extend beyond screens. Unlike a tablet that can be confiscated, smart home technologies are ambient, voice-activated, and embedded in the shared home environment [4, 57, 59], blurring the boundaries between shared and private spaces. As Sun et al. found, this shift introduces new categories of unanticipated combinations of physical and digital risk, such as a child unlocking a smart lock or purchasing items via voice commands [61]. Relatedly, in the integrated smart home environment, traditional strategies are difficult to apply when technologies operate across multiple devices and spaces. For instance, a parent cannot restrict a smart light, which children may treat as a toy, without potentially impacting other family members, nor can they easily monitor every single voice command.

This creates a theoretical disconnect. Parents face what Wisniewski et al. call an "impossible middle ground" as they are forced to choose between overly passive approaches that expose children to risks or overly restrictive measures that undermine trust and limit children's participation [71]. Sun et al. attribute this problem at least partially to the "all or nothing" approach in current smart home access control design, noting that parents lack the resources to apply flexible mediation across a system of connected devices [61]. In this context, we argue that the smart home represents a unique challenge for parental mediation, as it requires moving from mediating a technology to managing an environment. Our work addresses this gap by proposing "tension management," as a concept that moves beyond binary rules (allow/block) to capture the dynamic, real-time negotiations required to live in a shared, connected home. This reconceptualization extends parental mediation theory and informs HCI's broader discourse on family informatics and child-computer interaction.

2.3 Conducting Research with Children At Home

Research in childhood studies has explored listening to, consulting with, and researching with young children through various approaches and activities [12, 13, 28]. One notable example is the Mosaic approach [16], a multi-method framework developed based on the view that *"children are experts in their own lives."* It combines observation and interviews with participatory tools such as child-led home tours, photographs, and drawings to create a composite picture of children's experiences.

Child-led tours offer rich contextual insights by revealing physical settings and objects while enabling children to share their thoughts, feelings, and experiences [28]. Visual methods (e.g., drawings and photos) allow children to express ideas beyond spoken words [15, 16], and these visuals often serve as prompts for deeper discussion and reflection [15]. Through these activities, children articulate their understanding of living spaces, gain confidence, and experience pride in being heard by adults. This process empowers them to *"explore the ways in which they perceive the world and communicate their ideas in a way that is meaningful to them"* [63].

While numerous methods exist for studying children in their spaces, researchers must remain sensitive to children's diverse backgrounds and contexts, inviting creative approaches that respect these differences [14, 28]. As Green emphasizes, understanding children's perspectives is not only practical but also essential for shaping a vision for the future. When these young minds are empowered to believe their ideas matter, the impact can be profound [28]. Both the research focus on children's perspectives and the methods described by Green [28] reflect an intention to *"honor children and uphold their participatory right of expression for the betterment of our world both today and tomorrow."*

Recognizing the importance of situating smart home research in the actual home context, our study adapts Mosaic-inspired approaches for this domain. While child-led tours and visual prompts remain central, we incorporated technology-focused activities (e.g., exploring device interactions, design workbooks) to capture how children experience and imagine smart home technologies embedded in family life. Our approach addresses the unique challenges of studying ambient, integrated smart home systems where interactions are distributed across spaces and intertwined with family routines, ensuring that children's voices inform both empirical insights and design implications.

3 Study Design

Inspired by the Mosaic approach [16], our study engaged nine families with children aged 6–11 years using multiple methods to capture their perspectives in the home. We conducted child-led home tours, interviewed parents about their children's smart home experiences, and created a design workbook inspired by existing smart home research [20, 72] to engage child-parent interactions and reflections. Families completed the workbook at their own pace and shared their insights during an exit interview. Our adapted, four-step process is detailed in Figure 1. This study was approved by our university's Institutional Review Board (IRB).

3.1 Parental Interviews

We started with an hour-long parental interview, conducted via Zoom, aimed at contextualizing children's smart home experiences from the parents' perspectives (RQ1). This included introductions, parents' descriptions of their children, the parent-child relationship,

Figure 1: An overview of the four study steps: Step 1: A parental interview to inquire about children's smart home use and parent-child relationships. Step 2: A home visit including a child-led tour to observe and interview children to understand their smart home experiences and needs. Step 3: The use of a design workbook as a probe to facilitate the creative process for generating ideas and concepts with families. Step 4: An exit interview with both the parent and the child to learn about their experiences and input on the design workbook.

the role of smart home technologies in family relationships and routines, parents' perspectives on children's smart home access and participation, related issues and benefits, and descriptions of experienced parent-child conflicts due to different smart home needs and how they respond to such conflicts. Parents' answers helped us establish a baseline understanding of their smart home setup and provide a point of comparison to children's smart home experiences described during the child-led home tour. See the parental interview protocol in Appendix A.

3.2 Child-led Home Tour

Recognizing the importance of situating smart home research within the actual home context, and drawing on established methods from childhood studies (e.g., child-led tours) [12, 13, 28], we incorporated in-person home visits into our study. Each home visit generally lasted 1.5–2 hours, including a child-led tour of the family's smart home setup and an interview. These home visits allowed us to observe children's interactions with and access to smart home technologies, and hear children's explanations of related parental rules, their likes, dislikes, and experiences of specific devices (RQ1). Child assent was obtained before each session, and parents were also welcomed to join the tour. Parents mostly chose to stay nearby to observe and provide explanations as needed. We audio-recorded the tours and photographed the devices (no photos of children were taken). See the child-led tour protocol in Appendix B.

3.3 Design Workbook

While the first two steps contextualized children's lived smart home experiences from both parents' and children's perspectives, the third step using a design workbook aimed to provoke discussions and insights between child and parent participants that would guide families in generating shared designs about smart home futures (RQ2). Our workbook design was inspired by Desjardins et al.'s Bespoke workbook for non-conventional homes [20] and Wong et al.'s comic-style workbook illustrating tensions around monitoring cameras [72]. Both prior approaches used illustrated scenarios as probes to spark dialogue and support creative processes. Building on these ideas, we aimed to create a workbook that engaged both children and parents in shared reflection and ideation through illustrations that resonated with their lived experiences. To achieve this, the research team spent eight months iteratively developing the design workbook.[1]

First, we reviewed literature on the use of smart home technologies by families [51, 55, 57, 59] to identify popular device types (e.g., smart speakers, smart monitoring cameras, and smart thermostats) and use cases (e.g., supporting routines, monitoring children). We then created storyboards and scenarios about how families use different devices in diverse ways. Next, we developed activities and prompts, such as the "parent-child comparison table" (see Figure 2 D), "temperature detective" (see Figure 2 E), and "smart home safari" (see Figure 2 F), to engage families' reflections and ideations. To create a cohesive storyline, we also introduced a main character (see Figure 2 B) to accompany families on their smart home adventure to discover seven types of smart home technologies in the "Techie Town" (see Figure 2 C). This narrative depicts the interactions, needs, and sometimes conflicts between children and parents.

In our study, at the end of each home visit, we ended the session by introducing families the design workbook activities and provided them with a packet of drawing supplies (see Figure 2 A).

3.4 Exit Interview

Each family was given two to three months to complete the workbook. Upon completion of the workbook, we conducted in-person exit interviews (see the full script in Appendix C) with families to discuss the workbook content, their answers to the prompts, design ideas and feedback about the design workbook method itself. We chose in-person interviews to directly hear children's workbook responses and reflections, and photographed the contents of their

[1]The workbook is available in full in our OSF repository: https://osf.io/z9k5p/overview?view_only=3351a53418e64083af05821630b6da19

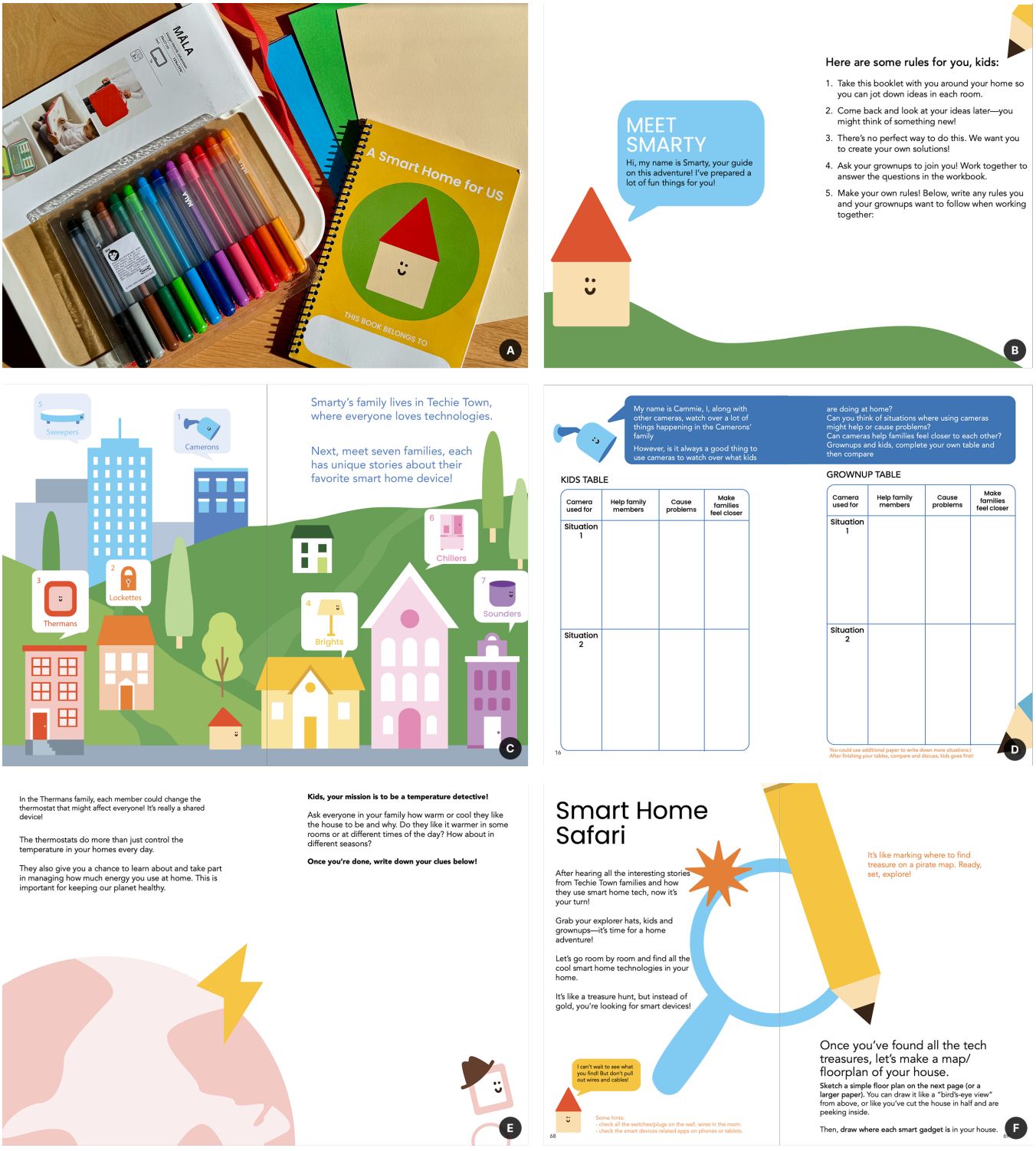

Figure 2: Sample design workbook pages. A: The workbook packet provided to each family. B: Introduction of the workbook's lead character, Smarty, introducing the workbook rules to families. C: Smarty's Techie Town neighborhood houses seven families, each having unique stories about their favorite smart home device. The families include: the Camerons, the Lockettes, the Thermans, the Brights, the Sweepers, the Chillers, and the Sounders. D: An example prompt asking the parent and the child to reflect on monitoring camera use benefits and issues by completing a table to compare and discuss reflections. E: An example prompt where the child interviews family members' preferences for home temperature to understand families' needs. F: An example prompt for families to go on a smart home safari exploration, identifying all smart devices to reflect on the roles they play in family life.

completed workbooks. Families kept the workbook as a memory of their participation.

3.5 Recruitment and Participating Families

Our study had four inclusion criteria. First, a participating family had to own multiple smart home devices (e.g., smart speakers/displays, cameras, lights) so that we could study how children navigate interconnected smart home systems. We did not specify the exact number, instead we asked interested participants to list out the types of devices they owned. Second, the family had to have at least one child aged 6–11 years who has access to and uses these technologies; we intentionally limited participation to one child per household to ensure balanced data representation across families. Third, at least one parent had to be available to participate with the child, sharing the parental perspectives of the child's smart home experiences. And fourth, the family lived in a geographic area that the research team could access within driving distance.

In Spring 2024, we started recruitment with the explicit goal of recruiting a diverse sample by using multiple channels through postings on social media platforms (e.g., local city subreddits and Facebook groups), institutional mailing lists, personal networks, as well as distributing flyers at local children's hospitals, libraries, and public school events to promote the study. All study procedures were explained during recruitment. After months of recruitment efforts, we recruited nine families (10 parents and 9 children, including both parents in Family 7) from the same geographic area, with children aged 6–11 years (see Table 1). Our participating families generally had above-average household incomes for the area and were highly educated (2 bachelor's degrees, 5 master's degrees, and 2 PhDs). All owned or were buying their homes; eight lived in detached houses and one in an apartment. Four families had members working in technology-related occupations, four in non-technical fields, and one identified as being in a tech-adjacent role. Each family was paid $20 for each of the four steps (parental interview, child tour, design workbook, and exit interview), and received an additional $40 for completing all four steps, for a total of $120.

3.6 Data Analysis

Our analysis is based on a rich dataset including audio transcripts from home visits, photographs, participant workbook answers and sketches, and researcher field notes. The first two authors first read through all the transcriptions to familiarize themselves with the data while conducting analytical memoing [37] and using both a theory-led deductive approach [54], and an inductive thematic analysis approach [7] to identify themes relevant to the research questions and existing theories (e.g., children's smart home use, parental mediation), while discovering emerging ones (e.g., children's trust and distrust in smart home technologies). We created three separate codebooks[2] to capture themes and codes for the parental interview, home visit, and exit interview discussing the workbook respectively. We located where each workbook page containing writing and drawings was mentioned in the parent, child, and exit interview transcripts while analyzing the content. We also drew comparisons and contrasts on instances where parents and children both shared their perspectives (e.g., smart home usage rules, benefits and issues of smart home technologies) to identify conflicts and tensions. The research team held weekly meetings to discuss and revise the codebooks iteratively until they captured a comprehensive set of themes.

[2]Codebooks are available in our OSF repository: https://osf.io/z9k5p/overview?view_only=3351a53418e64083af05821630b6da19

3.7 Limitations

Despite employing multiple recruitment channels to reach a diverse range of families (e.g., social media postings, flyers at libraries, children's hospitals, schools), our final sample was geographically and socioeconomically limited. This is largely because we prioritized recruiting families with comprehensive smart home setups. Families who acquire and maintain multiple smart devices in an interconnected smart home are likely more affluent, whereas single smart home devices (e.g., a smart speaker only) may be found in more economically diverse households. Relatedly, most parents held college or advanced degrees and reported above-average household incomes. As a result, our findings provide a snapshot of a small sample within a particular demographic, and thus it is an open question as to how our results would generalize to larger and more diverse groups of children and families. While small, our sample is still appropriate for in-depth qualitative research that seeks to understand lived experiences and generate design insights [7]. However, we acknowledge that our findings may not capture the full diversity of families' smart home experiences. Future work should extend this inquiry to more diverse family structures (e.g., blended families, grandparent families households), and households from broader socioeconomic backgrounds. Additionally, future studies should explicitly examine sibling interactions, which is a dynamic that surfaced as relevant in our participants' experiences, but remained outside the scope of this dyad-focused study.

4 Contextualizing Children's Lived Smart Home Experiences

To better contextualize our main findings in Sections 5 and 6, we briefly outline the smart home setups of the participating families. All the smart home technologies in the photos were introduced by and accessible to the child participants during the home tours. We use a letter with a number to represent families (e.g., F1 is Family 1), parents (e.g., P1 is the parent participant in Family 1), and children (e.g., C1 is child participant in Family 1).

In our sample, shared spaces like entryways, living rooms, and kitchens were commonly equipped with a range of devices, including doorbell cameras (see Appendix D Figure 8), smart locks controlled by apps (see Appendix D Figure 9), wall-mounted smart thermostats (see Appendix D Figure 10), and robot vacuums (see in Appendix D Figure 11). Smart speakers and displays were particularly prevalent on kitchen counters (see Appendix D Figure 12), with some families using multiple speakers and displays throughout the home for various purposes (see Appendix D Figure 13).

Some children had smart home technologies in their own bedrooms. For instance, C7 uses a Google Home Dot smart speaker for controlling lights (Figure 3, A and B), C8 and C9 use an Alexa speaker for managing routines (Figure 3, C and D), C5 has an Echo Dot speaker for music and adjusting smart blinds (Figure 3, E and F), and C4's bedroom has a monitoring camera and a smart button

ID	Participating Parent	Occupation	Child Age	Gender	Mentioned sibling	Speaker	Display	Thermo.	Light	Lock	Vacuum	Monitoring Cam	Others
F1	Dad	Tech	10	F	Older sister	•					•	•	
F2	Mom	Tech	9	F	None	•	•	•		•		•	
F3	Mom	Non-tech	8	F	None	•	•	•	•	•		•	Pet Care
F4	Mom	Tech	6	F	Younger sister	•	•	•	•	•	•	•	
F5	Mom	Tech	9	M	Older sister	•	•	•		•		•	Blinds
F6	Mom	Non-tech	7	F	Younger brother			•		•	•	•	
F7	Both	Tech-adjacent	9	F	None	•	•		•	•	•	•	
F8	Dad	Non-tech	10	F	Younger brother	•	•	•	•	•	•	•	
F9	Mom	Non-tech	11	F	Older sister	•		•	•	•	•	•	Pet feeder

Table 1: Participant demographics with smart home devices (•: smart home device used by children). F [number] represents the participating family number (e.g., F1 is family 1). Siblings were mentioned by the child or parent participants during the study.

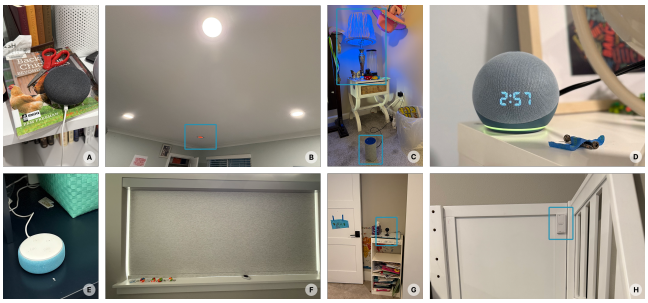

Figure 3: Devices in children's rooms. C7's smart speaker (A) that can be used to control smart lights on the ceiling (B); C9's room has a smart speaker that can control a smart lamp turned blue (C). C8's room has a smart speaker placed on a bookshelf (D); C5's bedroom has a smart speaker (E) sitting on a dark blue desk next to a woven storage basket and a smart blind (F); C4's bedroom has a black camera right by the door (G), and a smart light button on the bed frame (H).

for lights (Figure 3, G and H). Children in our sample had access to and could independently use many of these devices throughout their homes.

5 Families' Lived Smart Home Experiences

Following the contextualization of children's smart home experiences, this section presents families' lived smart home experiences, needs, and tensions that arise from children's use of smart home technologies, answering RQ1. We find that tensions arise when children's smart home needs are challenged, perceived differently by family members, or even negatively impacted by the technology itself. Thus, we differentiate between children's internal tensions (Section 5.1), parents' internal tensions (Section 5.2), and parent-child interpersonal tensions (Section 5.3).

5.1 Children's Internal Tensions

Overall, children experienced internal tensions centered on three aspects: (1) *autonomy vs. safety*, as they want autonomy and privacy but also appreciate the sense of safety from parental monitoring; (2) *digital attraction vs. self-regulation*, showing children's desires for unrestricted engagement with devices conflicting with their understanding and internalization of boundaries set by their parents; and (3) *technological reliance vs. performance skepticism*, where children have conflicted feelings of trusting and relying on technologies, with doubts arising from technology failures and privacy concerns.

5.1.1 Autonomy vs. safety: the ambivalence about monitoring. Monitoring cameras were present in all nine families' homes. Tensions regarding their use were a recurring theme, particularly for C1, C4, C6, and C7. These children often expressed a conflict between their desire for autonomy and their appreciation for the safety and connection the cameras provided.

For instance, C1 from F1 described this dual role when recounting how she sometimes used the living room camera to proactively communicate with her mom when she was out, saying, *"sometimes if I play a game like [with] my mom [by talking to her through the camera and asking] 'hello [mom], what are you doing? [I can] watch you'."* Yet, when her mom used the camera to check if C1 was doing homework when home alone, C1 felt *"like my mom is like hiding [behind the camera] and look at me."* As a result, C1 would sometimes intentionally avoid the camera area.

In a similar case, C4's response involved physically adjusting camera angles to "protest" this monitoring. During the home tour, she pointed to the camera in her shared bedroom, which she and her sister had purposefully turned to face the wall (see Figure 3 G). She explained this act of "protest" was a way to negotiate privacy: *"That means mama can't see us...that's what [C4's older sister] does when we have girl night out. She faces the camera that way [to the wall]."*

This desire for autonomy was also demonstrated when C4 described her reluctance to follow mom's reminders communicated through the camera: *"There's something I do also not like about the camera, because when I'm sleeping, when [I don't want to sleep] I want to play, and if I get out of bed in the night and I watch [look at the camera], she's [mom] going to look at, and then I will, then she's going to say '[C4's name] go to bed'."*

Despite these moments of rebellion, C4 also shared that the very same camera made her feel safe: *"it also makes me feel safe, because then when a grownup comes [after they see what happens via the monitoring camera if kids were playing rough], then they could stop the happening, so then we would be safe."*

These examples from C1 and C4, which reflect a theme also present in our home visits with C6 and C7, reveal children's developmental need to practice independence while still wanting parental protection, with technology becoming a contested space where these competing needs play out.

5.1.2 Digital attraction vs. developing self-regulation. Children want the freedom to play and explore, using smart home devices for fun or entertainment, yet they are faced with parental rules about time limits, content boundaries, and the intended purpose of the technology. While this leads to parent-child interpersonal tensions as we discuss more in Section 5.3, children also experienced internal struggles when transitioning from engaging with technology to other tasks and the process of learning self-regulation when external controls are not strictly enforced.

For example, C3 expressed frustration when her mother added a PIN to Netflix on their smart display: *"when mama put the pin code on Ziggy [the smart display name], I don't really want it then it would make me need to [ask mom], not be able to do Netflix whenever I wanted."* Still, C3 understood that she needed to adhere to mom's rule because *"to make sure I don't watch things that aren't good...So I can avoid the videos that I don't want to see."*

Similarly, C1 shared her struggle with transitioning away from using technology even though she understood prolonged use would be unhealthy for her: *"sometimes um I think...[using screen-based devices is] little bad...[after I use it for a while] my brain is changing badly and my eyes is like turning like red."*

These examples show children's developing capacity for self-regulation, as they begin to understand and internalize parental reasoning about healthy technology use even while experiencing frustration with restrictions. Children also demonstrate an emerging awareness of technology's potential negative effects on their well-being, yet they struggle with the immediate appeal of engaging content. It is evident from children's thoughts that the external parental controls gradually transform into children's internal self-regulation skills, with smart home technologies testing their practices for understanding boundaries and consequences.

5.1.3 Technological reliance vs. performance skepticism. Although children in our study were accustomed to living with smart home technologies and generally trusted them to be helpful, they also experienced doubts when devices malfunctioned. This led to children having conflicting feelings about smart home technology as both helpful and confidence-building, yet unreliable and frustrating.

C9 used her Alexa speakers daily for morning and bedtime routines, but she still shared doubts during the home tour: *"I kind of trust it [Alexa]...If I'm just having a conversation...I don't really trust it listening on us. But then if I'm just sitting in my room and listening to something not on it, I trust it...I don't really know if it's recording you and then the information might go somewhere...So you know how we were talking. It's [suddenly] like 'I can't help you with that'...I don't really like it because it's kind of creepy."*

Similarly, the conflict between trust and skepticism was clear with C7 and her Google Home speaker. Although C7 often uses it for music and controlling lights, its unreliability in a key moment quickly disappointed her. During the home tour, she tried to demonstrate a voice activated "dance party" setting, but the device failed to understand her repeated commands. This performance failure led to a moment of doubt in both the technology and her own ability:

> C7: *"Hey Google. Turn on dance party lights in Pinky lights."*
> Google Home: *"Sorry, I don't understand."*
> C7: *"Hey, Google. Turn on the pinky lights."*
> C7: *"Hey, Google change Pinky lights to dance party."*
> Google Home: *"Sorry, I don't understand."*
> C7: *"I don't think it works. Well. My mom can do it, so why couldn't I? Maybe it's also one of the things that Google does not understand. Oh, it sounds like maybe it's not that smart after all."*

From these examples, it is clear that children's trust in smart home technologies is context-dependent and conditional. Children in our study not only learned how to use and live with individual smart devices (e.g., speakers and cameras), but also adapted to a technologically mediated domestic space where privacy, autonomy, safety, and trust are negotiated through different interactions across interconnected systems. In this process, children demonstrated a growing understanding of technology's limitations and personalized these experiences, questioning both the technology's capabilities and their own abilities when interactions failed. This contrasts with adults who generally understand that tech glitches can be a normal part of digital experiences.

5.2 Parents' Internal Tensions

Parents experienced internal tensions regarding managing their children's use of smart home technology on: (1) *protective oversight vs. scaffolding independence*, where they balanced immediate safety controls against the need to foster long-term autonomy; (2) *system promise vs. management burden*, where the anticipated convenience of smart home integration was often influenced by maintenance demands and disruptions; and (3) *intended values vs. unintended lessons*, where parents struggled to reconcile their parenting goals with the conflicting behaviors that smart home technologies encouraged.

5.2.1 Protective oversight vs. scaffolding independence. Parents in our study grappled with how to use smart home technology for protection without undermining their children's growing independence. This tension was common, with parents weighing whether to implement strict technical controls, such as setting passcodes (P3), restricting access (P7), and tracking location (P5), or to trust their children to learn boundaries through experience. They constantly balanced the desire for immediate safety against the long-term goal of fostering trust, self-regulation, and independence.

For instance, P4 articulated this struggle as she deliberately chose not to activate parental controls on the family smart display placed on the kitchen counter. She explained that her children: *"need to learn where the boundaries are, instead of something [the parental controls] stopping them."* Similarly, P5 discussed using location tracking as a scaffold for independence rather than just surveillance. P5 noted that tracking could provide comfort when C5 felt nervous about biking to a friend's house alone, describing the strategy as: *"using the technology to allow kids to have a longer leash and kind of learn how to do things more independently, but still have sort of a safety net if needed."*

The choices made by parents like P4 and P5 illustrate the double-edged nature of these technologies. While offering convenient methods of monitoring and control, parents worried that these same features could hinder the very autonomy and trust they ultimately

want to foster, forcing them to decide when to intervene for safety and when to step back to allow for children's learning.

5.2.2 System promise vs. management burden. While parents in our study adopted smart home technologies, in the hope that interconnected systems and devices would work together to bring convenience, they faced unexpected challenges integrating them into family life without disrupting existing dynamics. They encountered frustrating device issues, unanticipated commercial content, and family interaction disruptions. The smart home's convenience promise sometimes became a complexity burden as parents managed interdependent systems rather than discrete devices.

When problems with one device could cascade across the system, parents weighed each change against potential impacts on existing automation. For instance, when setting up a child profile on C8's smart speaker, P8 encountered hidden fees and compatibility issues that risked breaking existing routines: *"I was worried that it would mess up all these kind of routines, because all that stuff's linked through my profile, and she doesn't have a phone...I would have to go in and mess with more stuff in my app to change profiles...I just didn't wanna make things even more complicated."* P8 also abandoned efforts to automate his robot vacuum through Alexa because the voice command was *"so obtuse and confusing to remember."* Such examples show how smart home system complexity turns device management into cost-benefit decision-making as parents rather choose simpler but less optimal solutions to avoid disruption.

Several parents described combing through smart display settings to improve children's safety, yet the unsatisfactory results left them unsure whether they had adequately proofed the devices. In the parental interview, P3 detailed disturbing news items and clickbait surfaced on an Echo Show and the difficulty of disabling them: *"We can't figure out how to turn off some of the skills on the [Amazon] Show so that they're not showing us news items that are really disturbing...I just saw one come up, and it was like [local] county murder...some of these click bait headlines that come up, she [C3] will say 'what is that about?'...It's always a prompt [from the smart display]...where the news does scare her...And I'm afraid of the way that that can come through in uncontrolled media. So it's frustrating that I can't figure out those basics."*

Even when accessing regular content, P7 shared how C7's use of the family smart display can be distracting: *"So I like to make sure we at least have dinner together as much as possible, and we'll be talking about something she [C7] won't know what something is, or I won't know how to explain something, and then we'll very quickly...ask the display...And so suddenly this time becomes like us, engaging with the display...she wants to go down the Wiki rabbit hole about that topic...But I feel like just as often it can become a distraction."*

These examples show that smart home technologies intended to simplify life often create new complexity and stress. Parents have to become technology managers, constantly troubleshooting, configuring, and mediating between devices and family needs. The emotional labor of making technology "family-friendly" falls on parents, as they navigate opaque settings, inadequate resources, and systems designed for individual adult users rather than family contexts.

5.2.3 Intended values vs. unintended lessons. Parents in our study recognized that children may perceive and experience technologies differently than intended. They described times when the goals driving parental decisions did not align with the child's lived experiences and expectations, or what parents hoped for their children's learning. This creates a disconnect between parents' goals for integrating smart home devices and children's actual interactions and interpretations.

For instance, P6 used monitoring cameras to communicate with her children while at work as an act of connection. Meanwhile, she understood that C6 experienced the monitoring as uncomfortable at times: *"if she's playing and I come on the camera and I say, 'hi [C6], I see you.' Then she might feel shy to think I've been watching her...if it's not her choice and deliberate to be watched...I feel like there's different body language [that shows C6 is uncomfortable with being watched]."*

This awareness also created internal tensions for parents about which values to pass on. P2 had always experienced trouble getting the family Alexa speaker to recognize her voice. While she intentionally avoided using the smart speakers, she still recognized the value of the devices and did not want to impose her own opinions onto C2: *"in our home we actively use smart devices, and they make our life overall easier in a lot of ways and have really useful features...I'm not necessarily motivated to explore because...it's kind of a source of tension. So what I don't see the value in for myself doesn't mean I think it's completely useless...I want my child to have those opportunities [to use and experience technologies]. Just because I have, or choose to have a limited understanding of those opportunities, I don't want to discourage my child from [using] them [smart home technologies]."* At the same time, P2 also pointed out her caution: *"I don't want C2 to over rely on technology because she's a child born into and being raised in this environment."*

P9 wrestled with whether convenience features, like automated pet feeders, might remove opportunities for children to learn responsibility: *"I think the hardest part, though, as an example is, what is that taking away from our interaction with [using smart home technologies]...as we are raising young humans and thinking about their interaction with the world and their responsibilities, are we doing a disservice by having this machine...feed the cats versus actually having to learn to think about this other living being, when do they need to get fed, interacting with them...So it's this balance of what are we missing teaching our kids about...versus having these machines...do stuff for you."*

Such internal tensions highlight parents' awareness that technology design is not value-neutral but actively shapes children's views in ways that may contradict parental goals. Parents struggle with the realization that convenience technologies might inadvertently teach children to expect automated solutions rather than developing personal responsibility and interpersonal skills. Despite parents' best efforts, the challenge remains that children might still experience and interpret these technologies in ways that parents cannot fully control or predict.

5.3 Parent-Child Interpersonal Tensions

The internal tensions of both parents and children are also surface through their interpersonal tensions, highlighting differing needs regarding autonomy, technology's purpose, routine enforcement, and commercialism.

5.3.1 Monitoring as care vs. surveillance. A core tension arose between parents' use of technology for monitoring, which they framed as care, and children's experience of it as a restriction of or discipline of their autonomy. This was previously seen when C4 turned her camera to the wall (see Section 5.1.1).

This dynamic was similarly demonstrated in the exit interview with C7 and P7. C7 recalled the camera that used to be in her room, telling her father *"you used to spy on me while I was sleeping and I did not like it...but [now] you took it [the camera] away...It's like this black round thing connected to a stand and you can also broadcast through it, but I suppose I was only sleeping, but it was still a little bit weird to know that someone might be watching me."* P7 explained his rationale was for safety and communication: *"we kept it so that...you could call for us and we would hear you right away...that wasn't really to monitor you. That was more to if we were outside or walking with the dogs or...run a quick errand...we could tell you, 'oh, we can see you the whole time' to make you feel better."*

This exchange reveals how the same technology can carry different meanings for parents and children, even when both parties have good intentions. Parents frame monitoring as care and connection, while some children experience it as surveillance and a constraint on their privacy at times. Parents tried to resolve this tension by explicitly articulating their protective intentions while also recognizing their children's legitimate growing needs.

5.3.2 Utility vs. play: conflicting views on technology purpose and engagement-driven design. Another source of family tension arose due to the engagement-driven nature of certain smart home devices. Parents typically adopted these technologies for utility, while children saw them as tools for fun. This was particularly true for smart speakers and displays in shared spaces such as kitchens or living rooms. Their appealing and interactive features naturally draw children's attention, while parents find themselves providing continuous reminders and education about appropriate use.

This tension was evident when children's playful exploration frustrated parents' utilitarian goals. C7, for instance, explained during the home tour: *"Well, they [my parents] don't like it when I asked Google [Home speaker] random question... my dad was like, 'make Google shut up or else I'm going to take that device out of here'."*

Smart displays were a particular point of tension. C4 explained she could watch YouTube on Google Home *"anytime...Sometimes we watch too much and then we just take [whatever video is showing up next]. But then [my parents] say you should ask us."* P4 shared her frustration regarding how the device design made boundary-setting difficult: *"the display devices do not have a way to control the fact that this is a kid, and you should only show YouTube kid or the controls around the type of videos that are showed. My kid likes to watch Peppa Pig, but then there are a lot of violent-induced Peppa Pig videos...intermixed with everything...So I don't think we figured out a way...to just put YouTube kids on it by default instead of YouTube."*

Parents recognize that this tension stems from deliberate design choices. P5 articulated the underlying challenge: *"I think they [children] would prefer to have more time and more freedom on that [accessing media content], but I know that I want them to have autonomy and be able to do things on their own. But then I also know that many of these devices are designed to engage kids as long as possible and override their sense of self-regulation."* This awareness highlights how technology design can undermine parental goals for fostering healthy technology relationships.

These examples illustrate how smart home technologies become sites of negotiation between children's natural attraction to engaging content and parents' desires for purposeful, controlled use. The design of these systems, optimized for engagement rather than family connections, often puts parents in the position of constantly managing and redirecting children's interactions rather than allowing the technology to serve its intended utility functions.

5.3.3 Routine enforcement: convenience vs. rigidity. Parents appreciated that smart home technology can offer convenience in managing children's routines, but the actual implementation can lead to interpersonal tension. Technology-mediated reminders or downtime features, intended for convenience and providing structure, can be perceived as rigid by children.

For instance, P8 used Alexa's bedtime reminder: *"when bedtime is coming, there's like an announcement that comes across the speakers and said, 'hey, time to get ready for bed'."* P8 sometimes also used the "drop-in" feature to check on C8 and her younger brother to enforce bedtime lights-out: *" If they're in bed, and I hear, could be like a crying sound, or fighting, or something going on...I would kind of do one of these drop-in calls...and kind of say, 'what's going on, are you guys okay, go to sleep'...that ability to monitor them...But I only do it when I hear a lot of noise, and it's past time for the lights to be out."* While P8 saw this as convenient routine management, C8 found it frustratingly inflexible: *"I mean, I should get to sleep earlier, but I don't really want...I couldn't turn on the light [after lights out] because [my brother] want to go to sleep, which was kind of an issue to me because I couldn't fall asleep and it helps me to read go to sleep."*

Similarly, P7's use of Google Home's "downtime" feature led to C7's frustration: *"she [C7] really wanted to circumvent downtime. So she was asking Google how to turn downtime off. But Google is like, 'I can't help you because it's downtime right now.' So she got really frustrated (P7)."* In both cases, the children ultimately had to comply with the rigid boundaries, with C7 summarizing the feeling of resigned acceptance during the home tour: *"Yeah, I mean it's just kind of like I have to get used to it."*

These examples illustrate how smart home technologies aid parental enforcement of routines and boundaries while children may experience these technological boundaries as inflexible. The technology thus reshapes family power dynamics by introducing a "seemingly neutral" third party that actually embeds parental control into the environment itself.

5.3.4 Commercial influence: consumer education vs. persuasive design. Smart speakers and displays exhibit a hidden agenda to promote content and products inside the family space [1, 2]. While some children had been taught not to engage with sponsored content or ads, there were times when devices promoting commercial content exploited children's limited understanding of advertising, creating conflict when children tried to engage with shopping features. This also undermines parental efforts to guide their children's values and protect them from manipulative design.

This battle often began before a device was even adopted. P6, for example, explained why their family intentionally decided not to purchase smart speakers: *"I'm really uncomfortable with this consumer aspect...if we did have a [smart speaker or display] I feel*

like my kids would be buying stuff all the time. Or trying to...but that AI [in the device] is listening to us and tailoring their recommendations for what to advertise, even if it wasn't like directly that we buy with our voices...that makes me very uncomfortable."

P6's concerns were realized in other families. After C3 accidentally ordered cat food via an Alexa prompt, P3 expressed frustration with the device's relentless commercialism and her inability to disable it: *"[the smart display]'ll cycle through different things to buy...I don't like it. I've tried to change the settings so that it doesn't do that, but it doesn't seem to work...But it is annoying that it does the shopping things."* This constant exposure to prompted shopping influenced C3 as she demonstrated understanding that shopping can be as easy as click of a button: *"we were...looking at Corgis [C3 wants to adopt a Corgi dog] that you could buy, and I said [to mom], 'oh, you need to press this button [to buy a Corgi]'."*

This tension reveals how smart home technologies can undermine parental authority by introducing commercial interests directly into family spaces. Parents find themselves competing not just with their children's desires, but with sophisticated business engagement agendas designed to promote consumption, creating an asymmetrical battle where corporate marketing strategies exploit children's developing capabilities regarding understanding commercial intent. The result is that parents must become constant educators about consumer manipulation while simultaneously trying to maintain trust in the very technologies they've brought into their homes for convenience and connection.

6 Families' Design Recommendations for Supporting Shared Smart Home Participation

In this section, answering RQ2, we present a synthesis of design recommendations and considerations, building on both the design problem spaces that families identified and the design ideas they developed in their workbooks, to envision a smart-home future. We conclude that it requires moving beyond individual-focused experiences and nuclear family assumptions to support diverse family structures through shared-use interfaces and inclusive co-design processes. Systems must balance children's safety with developmental agency through adaptive controls while providing built-in mechanisms for family negotiation and conflict resolution. Companies should avoid over-engagement and intentionally design for playful connection and shared attention. Creating smart home systems that accommodate diverse family structures and enable equitable participation across different ages and abilities is both ethically necessary and indicative of quality design.

6.1 Designing for Shared Family Accounts and Experiences

Parents in our study expressed frustration with the individual-centric design of smart home technologies, arguing it clashes with the reality of family life in shared spaces. This *"one person, one device"* model, as P5 noted, does not reflect family dynamics, particularly with devices located in shared spaces, like the kitchen smart speaker. She pointed to Netflix as an example, which forces a family to choose a single profile even when watching together: *"Why do I have to choose what I'm watching or my daughter is watching? Why can't I say we're both watching and we're watching together and that things [smart home technologies] do things for the both of us."* This 'One-Size-Fits-One' design choice also worried P9: *"how do we actually keep us together rather than split us into four different islands [when using smart home technologies]? I worry that if things are too customized and everyone's in their own little island of existence that we lose the actually coming together as a family."*

This design limitation extends to children's profiles, which parents found ineffective and overly restrictive. P3 described the kids' profile on her Amazon Echo display as having *"hardcore content filtering"* that blocked useful functions; and the *"supposedly kid-friendly like apps and games, are not actually kid-friendly or they can be very frustrating for her to use...they freeze, or they don't work."* This frustration led P3 to abandon the child profile feature and create a modified adult profile for C3, which shows that the individual profile model, when applied to family dynamics, often leads to cumbersome workarounds rather than seamless integration.

To address these issues, parents called for a fundamental shift towards a **family-centered smart home profile** architecture. Instead of the current individual profile approach, F7 envisioned a *"a shared family account where everybody's input kind of gets centralized somewhere. I do feel like something like that would be able to make a household run more efficiently versus like this individual user experience."* Ultimately, parents argued that for devices in shared spaces to actually serve families, their design must prioritize collective experiences to foster togetherness over individualized and separated customizations.

6.2 Designing for Family Tension and Compromise

"Families are messy...[companies can't assume] it's a harmonious nuclear family where everybody gets along and all those sorts of things;" P5's comment summarized the essence of family life and echoed the parent-child tensions presented in Section 5.3. This highlights an important consideration: instead of creating family tensions, smart home technologies in shared spaces should be designed to help families navigate disagreements when members have competing needs and preferences. Families suggested several ways to achieve this through technology design.

One proposed solution was **built-in conflict mediation**. For instance, in their workbook, C5 designed a turn-taking feature for smart speakers when family members want different music at the same time. C5 explained during the exit interview: *"if many people want to listen to the music, the first one that [it] hears, it'll play that. And then the second one [song based on the 2nd family member's command] is, say after the [first] song it will play that, and then it'll just keep doing that [to ensure everybody's commands are executed one after another]."*

Another approach involved **collaborative rule-setting**. While children suggested playful solutions, such as C4's approach asking Google Home to do *"Eeny, meeny, miny, moe,"* or C2's explanation that *"if you asked it too many things at once, it would say rock, paper, scissors for the lineup for to ask me things."* Parents saw a deeper opportunity, as P5 suggested, that smart home technologies could facilitate a family conversation during setup, prompting them to *"talk together about what rules and decide upon them."* The system could even offer suggestions like *"here's some common rules that*

families have," to guide family discussion and establish expectations early on.

Finally, parents wanted technology to support **context-aware compromise**. P6 noted that family needs change based on who is home. When she's alone, her preferences should be prioritized, but when *"everybody's home, then I can go along with something that's better for everybody."* She envisioned family settings that could recognize the context, such as whether the kids are home or not, and adjust accordingly. This feature could help mediate conflicts by defaulting to a state of compromise, acknowledging that shared technology requires a different approach than personal devices.

6.3 Designing for Child Development and Autonomy

Considering the tensions parents navigate in balancing protection with supporting children's autonomy (see Section 5.3.1), parents suggested that smart home technologies should be designed to **grow with children**, moving beyond a *"set it and forget it (P5)"* static approach. P5 noted her hope for an adaptive smart home system that could *"learn and see... where are they [children] at developmentally and what are they ready for?"* and then *"gradually add in sort of more access and freedom."* This would allow technology to support a child's learning to be independent, while still enabling parents to *"check in and override it if it wasn't getting it right."* This adaptive approach was a shared design suggestion by parents across several aspects.

First, parents wanted **flexible controls** and safe ways for young children to participate and learn. Rather than rigid restrictions, P6 suggested parental controls should allow parents to *"decide whether and how much independence to associate with the thing"* based on their child's readiness. For younger children, children themselves emphasized wanting to participate in smart home controls and activities rather than being excluded. For instance, C2 designed a friendly **child lock** on the thermostat in her workbook (see Figure 4 A): *"So when you press the buttons [to change temperature], it doesn't [actually] do anything, but it still looks like you changed it. But then after three or four seconds, it [the thermostat] goes back to how it was... Also, it might be good for [the child] learning how to use the thermostat."* C3 designed a **kid mode** for the thermostat to be friendly and playful (see Figure 4 B): *"If Tommy [the character] is still playing with it, it would send his fingerprint and switch it to kid mode, and every time Tommy touched it, it would be [showing] an emoji."* C3 thought it was important for children to receive a friendly response from the device. She further explained: *"If it was like if it [the thermostat] had [child's] fingerprint, there would switch to kid mode immediately. So then he [the child] couldn't change the temperature...in the kid mode...It could also maybe tell you stories [in the kid mode so it's welcoming and friendly for kids]."*

Second, as children grow, the adaptive smart home system could foster responsibility and life skills by granting them **gradual control** in stages. In the initial interview, P5 envisioned systems that could *"teach them some kind of ways of navigating on their own so they don't have to rely on us [to remind children about chores]."* This aligns with C7's notes that she *"like[s] challenges in life"* and wouldn't want technology to make things *"too easy."* She designed a clear hierarchy for who controls what as reflected in her drawings

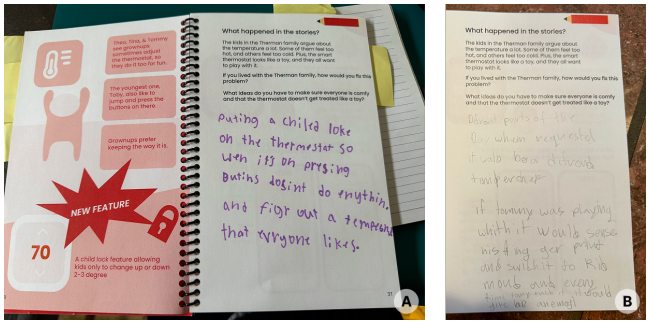

Figure 4: C2's design idea (A) of a child lock on the smart thermostat. If the lock is on, pressing buttons doesn't do anything. It also helps figure out a temperature everyone likes; C3's design idea (B) shows that a smart thermostat can automatically adjust to different temperatures at different times of the day. When requested, it changes settings so everyone feels comfortable. The thermostat can also recognize when kids are playing with it. Using fingerprint sensing, it switches into the kid mode, where it responds with emojis.

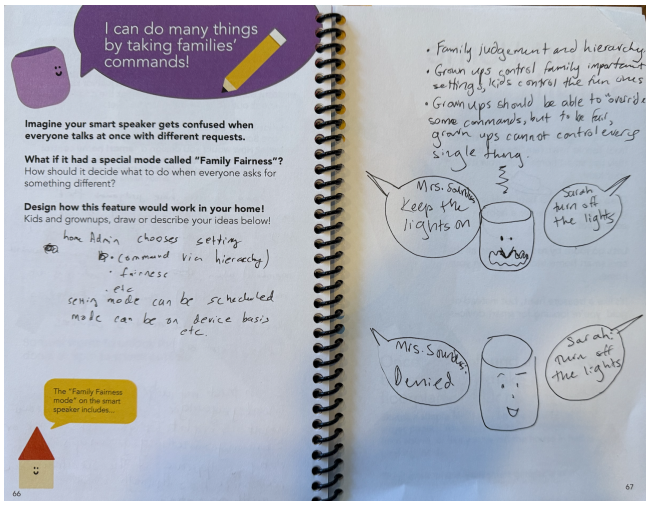

Figure 5: C7 illustrated how children should take over fun controls in the family rather than adults.

(Figure 5): *"Grownups control family important settings, and the kids control the fun ones...So in the house kids shouldn't be able to play with it unless given explicit permission by the grownups...grownups cannot control every single thing, but to be fair, grownups can't control the kids' lights or the kids' speakers."*

These perspectives show children's sophisticated understanding of shared participation and gradual responsibility. They suggest that a family-supportive smart home should start with **creating access and control opportunities for children to be involved in low-stakes aspects** (*"the fun ones"* according to C7) for learning and growth, while reserving critical functions for parents.

6.4 Designing for Content Safety and Resisting Manipulation

Building on parents' frustration with children's exposure to distracting and sponsored content (Section 5.3.2), they recognized the need for smart home technologies to prioritize content safety and resist manipulative tactics. More specifically, P3 found it *"unsafe"* for smart displays to *"automatically play something to a child,"* believing it is wrong to *"just spew content on people who haven't proactively chosen it."* This echoes P6's concerns over the lack of setting controls that prevent parents from establishing *"boundaries around how long to watch...[the children] feel like they want to be able to watch whatever they want [on the smart display]."* P6 wanted smart displays to provide more focused answers: *"get the one answer for the one thing you want to know, not get distracted by everything else."*

Beyond just avoiding distraction, parents envisioned devices that could serve as **proactive safety buffers**. P4 imagined a system that could recognize when a child accesses potentially unsafe content and intervene: *"[imagine] you [the child] have clicked on something, I [the technology] recognize 'you're a child, this is not a safe resource for you'... It would be a way for the tech itself to draw those lines and boundaries."* She also added that this would also *"encourage the child to see the parent as a safe resource,"* rather than handing them off fully to technologies for guidance.

Finally, parents wanted devices to **foster information literacy** instead of promoting blind trust. P7 explained the importance of teaching C7 where a device's answers come from, so C7 understands that *"Google is not just this God voice that's... omniscient."* P7 stressed that a device's answer should be seen as a *"first guess at the information,"* which the child should then learn to *"verify yourself."* This suggests a need for design mechanisms that transparently communicate information sources, helping children develop critical thinking skills about the digital information they consume.

6.5 Designing for Playfulness and Connection

Although smart home technologies are often adopted for convenience, families in our study saw potential for incorporating playfulness that serves a dual purpose: motivating engagement and participation, as well as fostering family connection. Parents recognized playfulness as both a practical strategy for involving children and a meaningful way to strengthen family bonds through shared experiences.

Some parents saw **playfulness as a practical strategy to motivate children's cooperation**, especially during chaotic moments. P1 recalled struggling to communicate with C1 amidst the chaos of busy home life, until P1 realized: *"if I can make those things [daily interactions] playful, I can buy in [get kids to agree on something easier]... making it playful is maybe a key to smart device for kids."* P1 imagined playful features on smart lights and vacuums *"[children] can play with the smart light application, and turn on and change the color. Or the robot vacuum...for example they can like stand in front of the robot [vacuum]...like some games, [the robot vacuum] with small mouth [in an fun appearance]...for kids."*

P1's ideas about playful smart home technologies extend beyond a child obeying parents' instructions to creating genuine engagement. Similarly, in their workbook, F5 designed a vacuum that

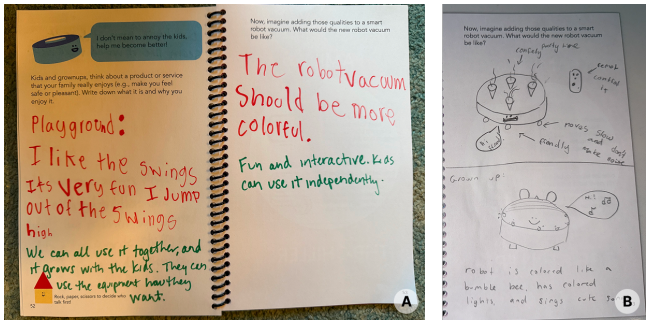

Figure 6: F6's design ideas of a robot vacuum being colorful and playful (A); F5's design ideas of a party robot vacuum spraying confetti and playing music (B)

incorporated party confetti and music (see Figure 6 B), adding playful and cheerful elements to bring families together. Similarly, P6 drew inspiration from playground experiences for their vacuum design in the workbook (see Figure 6 A), as F6 identified the playground as a space that helps parents and children bond and create shared memories.

Families also envisioned smart home technologies **using play to facilitate connection through shared experiences**. P3 imagined *"if you're having a smart device that is in a shared space, have some features that are just about fun, and about bringing people together around it. And that may be a game or something that prompts the people to be connected with each other rather than with it."* She suggested **asynchronous family games**, where the system could quiz family members on each other's answers to *"refresh some of this connection."* Similarly, P9 suggested group games like a computerized version of *"Simon Says,"* where the *"smart tech is like being Simon, and we all get to compete against each other,"* turning the device into a catalyst for family interaction. The key insight was to design features that **amplify moments of family joy**, helping technology build shared memories rather than compete for individual attention.

6.6 Designing for Age and Relational Diversity in Families

Parents expressed that smart home design often fails families because it assumes a traditional, *"harmonious nuclear family (P5)"* and ignores the reality of diverse family structures. This creates a need for systems that can adapt to different compositions, including LGBTQ+, blended, and multi-generational households. P3, who grew up in a household with *"friends and extended family coming in and out,"* wished for technology that could *"shift with that and can scale to support a broader network,"* such as by granting temporary access to a smart speaker for a chosen family member. This requires moving beyond rigid templates to allow for more flexible user roles and relationships.

Another challenge is designing for inclusivity across different user groups with various ages and abilities. P3 noted that *"ageism is so rampant,"* with technology often ignoring both children and elders, meaning the *"life stage needs that can better be supported by technology aren't even on the table."* P3 stressed the importance of the *"nothing about us without us mentality...think about technology*

designed, not just for kids, but with kids, at the center of the conversation," arguing that to ensure everyone can participate meaningfully, **technology must be designed with diverse users, not just for them.**

To achieve this inclusivity requires involving families and experts in the design process. P7 argued that tech companies are *"failing themselves"* if they don't actively seek *"input of families,"* as developers and designers might not *"know how families at a microscopic level need things"* especially since families are different from each other: *"Even we have a family but we don't have a family like everybody."* This means going beyond assumptions and actively **seeking input from various family types during design and development**.

P2 framed this as a matter of professional responsibility, stating that *"it's time for everyone, for all tech developers to take seriously...the commitment to design for the values and lives of groups of people who are actually using their devices. And that includes children and families...at this point it's the professional thing to do, the ethical thing to do. It's a marker of quality."* She added that since diverse families are already paying customers of such smart home products and services, **designing for their needs is not just morally right but economically sensible**: *"Having a product that doesn't understand how [different] users use it, that doesn't support users' needs is, and then charging for that product, in this day and age is just insulting...And not only that, but families, people who with disabilities and who are not fluent in English or have lower technical skills are...also paying money for these technologies."*

7 Discussion

We first synthesize our findings with respect to our research questions. Next, we discuss how our findings contribute to the understanding of families' use of technology and parental mediation in smart homes. We then propose practical guidelines for family-centered smart home design.

7.1 Mapping of Identified Tensions and Design Recommendations

Figure 7 synthesizes our findings for RQ1 and RQ2, illustrating how the internal tensions of parents and children often manifest as four types of interpersonal tensions, and mapping these to relevant design recommendations proposed by families. We note that this mapping is illustrative rather than exhaustive. For instance, while the specific design recommendations could potentially address the surfaced tensions, they are holistic design considerations (detailed in Section 6) touching on broader complexities of families' smart home experiences beyond specific tensions.

First, the tension of *Monitoring as Care vs. Surveillance* frequently surfaces when parents' anxiety regarding *protection* leads them to monitor, which conflicts with the child's desire for *autonomy*. Families proposed *Designing for Shared Family Accounts and Experiences* to better reflect family dynamics, alongside *Designing for Child Development and Autonomy* to provide adaptive controls that evolve with the child's growth.

Second, *Utility vs. Play* reflects a misalignment between children's attraction to play and engage with the devices, and the parents' desire for purposeful, controlled use. While smart home technologies are rarely designed with play as a primary utility, families suggested that *Designing for Playfulness and Connection* could bridge this gap by incorporating built-in playful mechanisms that facilitate bonding.

Third, *Routine Enforcement: Convenience vs. Rigidity* tensions often occur when parents use technology to offload the *management burden* of daily routines. This strategy creates friction when children might be skeptical of the device's reliability, rejecting its "rigid" authority. Key opportunities to resolve this include *Designing for Family Tensions and Compromise*, and *Designing for Age and Relational Diversity* to ensure systems adapt to diverse family structures.

Finally, to counter the external pressure of *Commercial Influence*, where persuasive design exploits the child's limited understanding and developing self-regulation, systems should *Prioritize Content Safety* and avoid over-engagement and distracting designs.

7.2 Reconceptualizing Parental Mediation for Smart Homes

Prior work shows that parents combine mediation strategies that shift as children's needs evolve and as new technologies emerge [17, 39]. Our findings reveal that parents employ multiple, sometimes conflicting, mediation strategies in smart homes. Such *simultaneously conflicted mediation* describes parents' deliberate choice of inconsistent strategies to balance protection and autonomy within systems optimized for individual use. Individual-centric designs that prioritize convenience and control over shared family dynamics and collaboration heighten these frictions. For example, P3 engaged in active mediation by discussing promoted content with C3 while also using a passcode for the Netflix app on the smart display (restrictive mediation). Family 7 co-used Google Home for shared activities (co-use) yet enforced automated downtime (technical restriction). This mix also appears when P6 avoided smart speakers due to commercialization concerns (non-adoption as restrictive mediation), whereas P4 declined parental controls to cultivate her child's self-regulation.

Interconnected smart home devices, each affording different features and functions, complicate conventional parental mediation assumptions in two key ways. First, **a ubiquitous mediation burden** emerges when multiple connected devices distributed across rooms reduce "tech-free" spaces and require system-level, not device-by-device, mediation. Parents face a persistent trade-off between safety/control and trust/autonomy (Section 5.2.1). They also manage disruptions introduced by smart home technologies and reconcile their intentions with children's different experiences (Section 5.2.3). The pervasiveness of these technologies creates ongoing negotiation and emotional labor that extends beyond traditional screen-time or online-risk concerns [17, 44] to encompass children's developing agency in smart home experiences.

Second, **spatial and environmental mediation** at home becomes relevant beyond device-specific approaches. Smart homes can be a "catalyst or a battleground" [42] where parent-child needs collide. For instance, children's bedrooms become contested spaces where parental utility and protection goals (e.g., P4 checking on C4 via a camera, P8 using a smart speaker to remind C8 about bedtime) contrast with children's needs for play and agency in

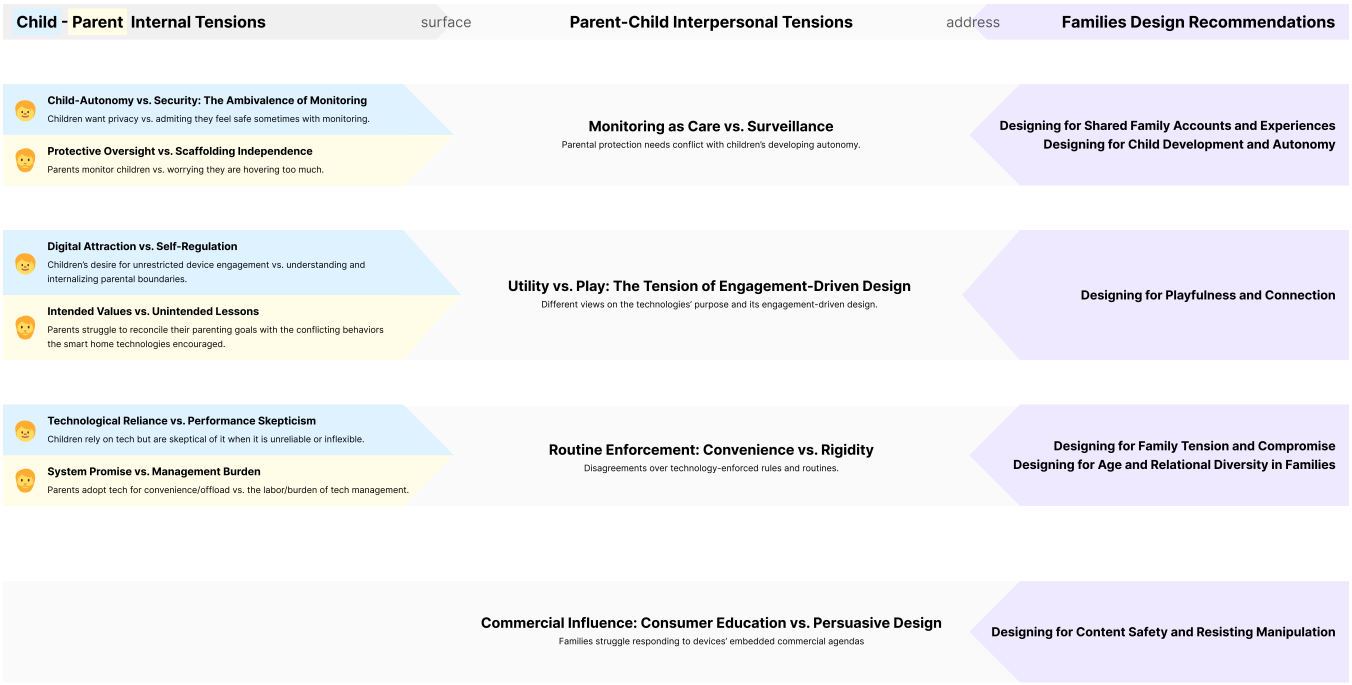

Figure 7: Overall summary of our findings, mapping identified internal and parent-child tensions to families' design recommendations for smart home technologies.

their own rooms. In Family 3, placing a smart display in the dining area disrupted a communal space intended for connection. Families therefore engage in ongoing conversations and negotiations. As Livingstone notes, technology often becomes the explicit terrain for these negotiations, which can be "exhausting and demoralizing," sometimes amplifying rather than easing family strain [42].

Meanwhile, children experience their own internal conflicts (Section 5.1), especially their conflicted rationalization of weighing the discomfort of being monitored against the feeling of being protected by cameras. This internal tension echoes the broader societal discourse on the normalization of surveillance culture, where individuals are trained to trade privacy for perceived safety or functional benefits [62, 77]. By embedding monitoring into the home environment, children might be primed to internalize logics of surveillance [36], while simultaneously being datafied from their routines to the value of family life as a part of the platform economies [49, 50].

Despite this pervasive technological system of control, children are not merely subject to parental rules but act as agents within parent- and technology-mediated home environments. Their actions, such as physically turning cameras away or attempting to circumvent downtime to reclaim spaces where they can be themselves signal a need for agency and challenge the traditional parental mediation view focused on parental authority.

These parent-child dynamics show that interconnected smart homes challenge conventional mediation assumptions. The ubiquitous burden and spatial mediation together produce conditions in which both parents and children are active agents negotiating competing needs. The parental mediation strategies we observe are surface expressions of ongoing reflection and debate about how to handle these trade-offs. Parents' use of *simultaneously conflicted mediation* is the norm as they reconcile opposing values like protection and autonomy. This suggests a reframing of parental mediation in smart homes as *a dynamic process of tension management* rather than the application of a stable strategy. This reframing shifts implications for both family technology design and parental support. It points to the need for design and educational tools and resources that acknowledge and work with family complexity, rather than imposing simplistic top-down parental controls.

7.3 A Way Forward: Family-Centered Design Considerations to Practices

Throughout this study, parents conveyed a clear desire for a fundamental shift in how technology is designed for shared home spaces and family use: do not treat family members as isolated users. From P5's frustration with the individual profile design approach *"that's not one person per one device. Multiple people use the kitchen [smart speaker] device,"* to P9's hope that smart home technologies could *"actually keep us together rather than split us into four different...own little island[s]."* Families advocated for family-centered rather than individual-centric design. This call for change goes beyond technical preferences to fundamental questions about meaningful participation in shaping the technologies that affect families' daily lives.

These insights reveal a key discrepancy between current design assumptions and the reality of family life, where shared experiences are the norm. From our findings, three critical design shifts emerge

to guide the transition toward a family-centered smart home as we discuss next in more detail.

7.3.1 From individual-centered to family-centered technology. Current systems often force families to choose a single user profile even during shared activities, which misrepresents how families live. As P5 described: *"why do I have to choose that I'm watching or my daughter's watching, why can't I say we're both watching?"* A family-centered approach must support genuine collaborative experiences, not just sum individual preferences. This requires designing systems that recognize and adapt to a shared family mode. For example, a smart TV could detect when a parent and child are watching together and suggest co-viewing content, rather than defaulting to a single profile. When multiple family members interact with a system, it could enter a collaborative mode that blends preferences based on who is present, rather than forcing an either/or choice. Future work should use participatory design to engage families in envisioning and prototyping these *shared family interaction modes*. Relatedly, these co-designed solutions require empirical testing to understand how families actually use and benefit from such features in their daily lives, moving beyond the ideation phase to real-world testing of family-centered design approaches.

7.3.2 Mediating family tensions, negotiations, and conflicts. Family life is inherently messy and filled with negotiation [45], and our findings show how engagement-driven design can exacerbate these tensions. If technology contributes to family tensions, then its design should also provide mechanisms to help resolve them, rather than leaving parents having to exhaustively manage them.

Prior work has found that technology-mediated transitions, such as those for screen time, are often more successful than parent-mediated ones [35]. This resonates with parents' perspectives in our study, such as P4 mentioning that children accept rules more easily from a seemingly neutral third party: *"[kids will think] a device is telling me [to stop]...we're [the parents] not the face of the evil...It is this objective, inanimate thing [technology]."* Building on this technology-mediated approach, smart home systems should anticipate and mediate the tensions they create. For example, during setup, systems could invite families to discuss and agree on rules together, taking the burden off the parent as the sole enforcer. During use, there could be system-initiated check-ins to elicit children and parents' user experiences and facilitate rule modifications if needed. Additionally, turn-taking, voting, and rock-paper-scissors were frequently suggested mechanisms to resolve disagreement over shared technology use. So smart systems, as a relatively trustworthy third-party objective agent (as described by P4), could incorporate such visible mediation mechanisms that appear to be fair to children.

Future research should investigate how these features impact family communication and negotiation. The goal is not to eliminate disagreement, but to design systems that take responsibility for the tensions they create and actively support families in navigating them.

7.3.3 Supporting children's development. A key challenge identified in our study is that static smart home controls fail to keep up with dynamic family life. Children continuously develop new needs and capabilities, yet many settings are, as P5 noted, *"sort of set it and forget it."* This creates a constant burden for parents to manually adjust settings to match their children's evolving needs.

Echoing prior work on developing technologies considering children's development [6, 66], we propose that smart home systems should adapt to children's development. Such systems could automatically suggest permission adjustments based on a child's age, demonstrated responsibility, and family priorities. This directly addresses the parental tension between granting autonomy and ensuring safety. For example, this could be achieved through differentiated interfaces on shared devices. As envisioned by the children in our study, a thermostat could have a playful, interactive "kid's mode" while simultaneously showing parents full controls. Over time, parents could gradually grant access to more complex features. This approach recognizes children as growing individuals and allows the system to evolve with them, supporting their journey toward digital competence and responsibility.

Creating such adaptive smart home systems will require interdisciplinary collaboration among designers, researchers, and families. Future work should investigate how to accurately assess a child's readiness for more autonomy and how to design systems that can accommodate diverse family values and child-rearing approaches across different cultural contexts.

8 Conclusion

Through an adapted Mosaic approach with nine families, this study uncovered children's lived experiences and parent-child tensions that arise from smart home use. Our findings identify four key areas of conflict: the struggle between parental protection and children's growing need for autonomy; differing views on technology's purpose; disagreements over technology-enforced routines; and children's vulnerability to embedded commercialism. Our work contributes to reconceptualizing parental mediation as a process of "tension management" rather than the application of static rules. We also translate this concept into actionable design considerations that guide a fundamental shift from individual-centric to family-centered technology design that acknowledges, supports, and adapts to the fluid, complex, and negotiated reality of modern family life.

Acknowledgments

We are sincerely grateful to the participating children and their parents; this work would not have been possible without their support. We also appreciate the families who reached out to show interest in our work. A special thanks goes to those who helped spread the word and recruit for this project. We also thank the editorial team and reviewers for their valuable insights and time. Kaiwen Sun was supported by the University of Michigan Rackham International Student Fellowship and a Meta Research PhD Fellowship.

References

[1] Amazon Ads. 2025. Alexa Home Screen. Online. https://advertising.amazon.com/resources/ad-specs/alexa-display-ads/home-screen

[2] Amazon Ads. 2025. Audio Marketing and Advertising Explained. Online. https://advertising.amazon.com/library/guides/audio-marketing

[3] Noah Apthorpe, Pardis Emami-Naeini, Arunesh Mathur, Marshini Chetty, and Nick Feamster. 2022. You, me, and IoT: How internet-connected consumer devices affect interpersonal relationships. *ACM Transactions on Internet of Things* 3, 4 (2022), 1–29. doi:10.1145/3539737

[4] Erin Beneteau, Ashley Boone, Yuxing Wu, Julie A Kientz, Jason Yip, and Alexis Hiniker. 2020. Parenting with Alexa: exploring the introduction of smart speakers on family dynamics. In *In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, 217:1–217:13. doi:10.1145/3313831.3376344

[5] Erin Beneteau, Olivia K Richards, Mingrui Zhang, Julie A Kientz, Jason Yip, and Alexis Hiniker. 2019. Communication breakdowns between families and Alexa. In *ACM Conference on Human Factors in Computing Systems (CHI)*. Association for Computing Machinery, 243:1–243:13. doi:10.1145/3290605.3300473

[6] Marina Umaschi Bers. 2012. *Designing digital experiences for positive youth development: From playpen to playground*. Oxford University Press.

[7] Virginia Braun and Victoria Clarke. 2021. Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and psychotherapy research* 21, 1 (2021), 37–47. doi:10.1002/capr.12360

[8] Rita Brito, Rita Francisco, Patrícia Dias, and Stephane Chaudron. 2017. Family dynamics in digital homes: The role played by parental mediation in young children's digital practices around 14 European countries. *Contemporary Family Therapy* 39, 4 (2017), 271–280. doi:10.1007/s10591-017-9431-0

[9] George Chalhoub, Martin J Kraemer, Norbert Nthala, and Ivan Flechais. 2021. "It did not give me an option to decline": A Longitudinal Analysis of the User Experience of Security and Privacy in Smart Home Products. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 555, 16 pages. doi:10.1145/3411764.3445691

[10] Fong-Ching Chang, Chiung-Hui Chiu, Ping-Hung Chen, Jeng-Tung Chiang, Nae-Fang Miao, Hung-Yi Chuang, and Shumei Liu. 2019. Children's use of mobile devices, smartphone addiction and parental mediation in Taiwan. *Computers in Human Behavior* 93 (2019), 25–32. doi:10.1016/j.chb.2018.11.048

[11] Chola Chhetri and Vivian Genaro Motti. 2022. User-Centric Privacy Controls for Smart Homes. *Proceedings of the ACM on Human-Computer Interaction* 6, CSCW2 (2022), 1–36. doi:10.1145/3555769

[12] Alison Clark. 2001. How to listen to very young children: The mosaic approach. *Child Care in Practice* 7, 4 (2001), 333–341. doi:10.1080/13575270108415344

[13] Alison Clark. 2004. The Mosaic Approach and Research with Young Children. In *The Reality of Research with Children and Young People*, Vicky Lewis, Mary Kellett, Chris Robinson, Sandy Fraser, and Sharon Ding (Eds.). SAGE, London, UK, 142–161.

[14] Alison Clark. 2005. Listening to and involving young children: A review of research and practice. *Early child development and care* 175, 6 (2005), 489–505. doi:10.1080/03004430500131288

[15] Alison Clark. 2011. Breaking methodological boundaries? Exploring visual, participatory methods with adults and young children. *European early childhood education research journal* 19, 3 (2011), 321–330. doi:10.1080/1350293X.2011.597964

[16] Alison Clark and Peter Moss. 2005. *Spaces to play: More listening to young children using the Mosaic approach*. Jessica Kingsley Publishers.

[17] Lynn Schofield Clark. 2011. Parental mediation theory for the digital age. *Communication theory* 21, 4 (2011), 323–343. doi:10.1111/j.1468-2885.2011.01391.x

[18] Scott Davidoff, Min Kyung Lee, Charles Yiu, John Zimmerman, and Anind K Dey. 2006. Principles of smart home control. In *ACM International Conference on Ubiquitous Computing (UbiComp)*. Association for Computing Machinery, 19–34. doi:10.1007/11853565_2

[19] Audrey Desjardins, Heidi R Biggs, Cayla Key, and Jeremy E Viny. 2020. IoT data in the home: Observing entanglements and drawing new encounters. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13. doi:10.1145/3313831.3376342

[20] Audrey Desjardins, Cayla Key, Heidi R Biggs, and Kelsey Aschenbeck. 2019. Bespoke booklets: A method for situated co-speculation. In *Proceedings of the 2019 on Designing Interactive Systems Conference*. 697–709. doi:10.1145/3322276.3322311

[21] Audrey Desjardins, Jeremy E Viny, Cayla Key, and Nouela Johnston. 2019. Alternative avenues for IoT: Designing with non-stereotypical homes. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13. doi:10.1145/3290605.3300581

[22] Stefania Druga, Randi Williams, Cynthia Breazeal, and Mitchel Resnick. 2017. "Hey Google is it ok if I eat you?" Initial explorations in child-agent interaction. In *Proceedings of the 2017 conference on interaction design and children*. 595–600. doi:10.1145/3078072.3084330

[23] Radhika Garg and Hua Cui. 2022. Social contexts, agency, and conflicts: Exploring critical aspects of design for future smart home technologies. *ACM Transactions on Computer-Human Interaction* 29, 2 (2022), 1–30. doi:10.1145/3485058

[24] Radhika Garg, Hua Cui, Spencer Seligson, Bo Zhang, Martin Porcheron, Leigh Clark, Benjamin R Cowan, and Erin Beneteau. 2022. The last decade of HCI research on children and voice-based conversational agents. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–19. doi:10.1145/3491102.3502016

[25] Radhika Garg and Subhasree Sengupta. 2020. He is just like me: a study of the long-term use of smart speakers by parents and children. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 4, 1 (2020), 1–24. doi:10.1145/3381002

[26] Christine Geeng and Franziska Roesner. 2019. Who's In Control? Interactions In Multi-User Smart Homes. In *ACM Conference on Human Factors in Computing Systems (CHI)*. Association for Computing Machinery, 268:1–268:13. doi:10.1145/3290605.3300498

[27] Murray Goulden. 2021. 'Delete the family': platform families and the colonisation of the smart home. *Information, Communication & Society* 24, 7 (2021), 903–920. doi:10.1080/1369118X.2019.1668454

[28] Carie Green. 2012. Listening to children: Exploring intuitive strategies and interactive methods in a study of children's special places. *International Journal of Early Childhood* 44, 3 (2012), 269–285. doi:10.1007/s13158-012-0075-9

[29] Neilly H. Tan, Brian Kinnee, Dana Langseth, Sean A. Munson, and Audrey Desjardins. 2022. Critical-playful speculations with cameras in the home. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–22. doi:10.1145/3491102.3502109

[30] Neilly H. Tan, Richmond Y. Wong, Audrey Desjardins, Sean A. Munson, and James Pierce. 2022. Monitoring Pets, Deterring Intruders, and Casually Spying on Neighbors: Everyday Uses of Smart Home Cameras. In *ACM Conference on Human Factors in Computing Systems (CHI)*. Association for Computing Machinery, 617:1–617:25. doi:10.1145/3491102.3517617

[31] Tom Hargreaves, Richard Hauxwell-Baldwin, Charlie Wilson, Mike Coleman, Tom Kane, Lina Stankovic, Vladimir Stankovic, David Murray, Jing Liao, Steven Firth, et al. 2015. Smart homes, control and energy management: How do smart home technologies influence control over energy use and domestic life? In *European Council for an Energy Efficient Economy (ECEEE) 2015 Summer Study Proceedings*. 1022–1032.

[32] Tom Hargreaves and Charlie Wilson. 2017. *Smart homes and their users*. Springer. doi:10.1007/978-3-319-68018-7

[33] Tom Hargreaves, Charlie Wilson, and Richard Hauxwell-Baldwin. 2013. Who Uses Smart Home Technologies? Representations of Users by the Smart Home Industry. Online. In *Proceedings of the European Council for an Energy Efficient Economy (ECEEE) Summer Study on Energy Efficiency in Buildings*. European Council for an Energy Efficient Economy, 1769–1780. https://proceedings.eceee.org/papers/proceedings2013/6-241-13_Hargreaves.pdf

[34] Tom Hargreaves, Charlie Wilson, and Richard Hauxwell-Baldwin. 2018. Learning to live in a smart home. *Building Research & Information* 46, 1 (2018), 127–139. doi:10.1080/09613218.2017.1286882

[35] Alexis Hiniker, Hyewon Suh, Sabina Cao, and Julie A Kientz. 2016. Screen time tantrums: How families manage screen media experiences for toddlers and preschoolers. In *Proceedings of the 2016 CHI conference on human factors in computing systems*. 648–660. doi:10.1145/2858036.2858278

[36] Donell Holloway. 2019. Surveillance capitalism and children's data: the Internet of toys and things for children. *Media International Australia* 170, 1 (2019), 27–36. doi:10.1177/1329878X19828205

[37] Karen Holtzblatt, Jessamyn Burns Wendell, and Shelley Wood. 2004. *Rapid contextual design: a how-to guide to key techniques for user-centered design*. Elsevier. doi:10.1016/B978-0-12-354051-5.X5000-9

[38] ICO. 2023. Annex B: Age and developmental stages. https://ico.org.uk/for-organisations/uk-gdpr-guidance-and-resources/childrens-information/childrens-code-guidance-and-resources/age-appropriate-design-a-code-of-practice-for-online-services/annex-b-age-and-developmental-stages/

[39] Hee Jhee Jiow, Sun Sun Lim, and Julian Lin. 2017. Level up! Refreshing parental mediation theory for our digital media landscape. *Communication Theory* 27, 3 (2017), 309–328. doi:10.1111/comt.12109

[40] Josephine Lau, Benjamin Zimmerman, and Florian Schaub. 2018. Alexa, are you listening? Privacy perceptions, concerns and privacy-seeking behaviors with smart speakers. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (2018), 102:1–102:31. doi:10.1145/3274371

[41] Jingjie Li, Kaiwen Sun, Brittany Skye Huff, Anna Marie Bierley, Younghyun Kim, Florian Schaub, and Kassem Fawaz. 2023. "It's up to the Consumer to be Smart": Understanding the Security and Privacy Attitudes of Smart Home Users on Reddit. In *IEEE Symposium on Security and Privacy (SP)*. IEEE Computer Society Los Alamitos, CA, 380–396. doi:10.1109/SP46215.2023.10179344

[42] Sonia Livingstone and Alicia Blum-Ross. 2020. *Parenting for a digital future: How hopes and fears about technology shape children's lives*. Oxford University Press, USA.

[43] Sonia Livingstone and Ellen J Helsper. 2008. Parental mediation of children's internet use. *Journal of broadcasting & electronic media* 52, 4 (2008), 581–599. doi:10.1080/08838150802437396

[44] Sonia Livingstone, Giovanna Mascheroni, Michael Dreier, Stephane Chaudron, and Kaat Lagae. 2015. How parents of young children manage digital devices at home: The role of income, education and parental style. (2015).

[45] Sonia Livingstone and Julian Sefton-Green. 2024. The Platformization of the Family. In *The Platformization of the Family: Towards a Research Agenda*. Springer Nature Switzerland Cham, 7–23. doi:10.1007/978-3-031-74881-3_2

[46] Sonia Livingstone, Mariya Stoilova, and Rishita Nandagiri. 2019. *Children's data and privacy online: growing up in a digital age: an evidence review.* Technical Report. London School of Economics and Political Science. http://eprints.lse.ac.uk/101283/1/Livingstone_childrens_data_and_privacy_online_evidence_review_published.pdf
[47] Maria Grazia Lo Cricchio, Benedetta E Palladino, Androulla Eleftheriou, Annalaura Nocentini, and Ersilia Menesini. 2022. Parental mediation strategies and their role on youths' online privacy disclosure and protection: A systematic review. *European Psychologist* 27, 2 (2022), 116. doi:10.1027/1016-9040/a000450
[48] Davit Marikyan, Savvas Papagiannidis, and Eleftherios Alamanos. 2019. A systematic review of the smart home literature: A user perspective. *Technological Forecasting and Social Change* 138 (2019), 139–154. doi:10.1016/j.techfore.2018.08.015
[49] Giovanna Mascheroni and Donell Holloway. 2019. The quantified child: Discourses and practices of dataveillance in different life stages. In *The Routledge handbook of digital literacies in early childhood.* Routledge, 354–365. doi:10.4324/9780203730638-26
[50] Giovanna Mascheroni, Andra Siibak, et al. 2021. *Datafied childhoods: Data practices and imaginaries in children's lives.* Peter Lang. doi:10.3726/b17460
[51] Kathryn L Modecki, Rachel E Goldberg, Pamela Wisniewski, and Amy Orben. 2022. What is digital parenting? A systematic review of past measurement and blueprint for the future. *Perspectives on Psychological Science* 17, 6 (2022), 1673–1691. doi:10.1177/17456916211072458
[52] James Pierce. 2019. Lamps, Curtains, Robots: 3 scenarios for the future of the smart home. In *Proceedings of the 2019 Conference on Creativity and Cognition.* 423–424. doi:10.1145/3325480.3329181
[53] Rosslin John Robles and Tai-hoon Kim. 2010. A review on security in smart home development. *International Journal of Advanced Science and Technology* 15 (2010).
[54] Johnny Saldaña. 2021. *The coding manual for qualitative researchers.* Sage.
[55] Ji Youn Shin, Minjin Rheu, Jina Huh-Yoo, and Wei Peng. 2021. Designing technologies to support parent-child relationships: a review of current findings and suggestions for future directions. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW2 (2021), 1–31. doi:10.1145/3479585
[56] Wonsun Shin, Jisu Huh, and Ronald J Faber. 2012. Tweens' online privacy risks and the role of parental mediation. *Journal of Broadcasting & Electronic Media* 56, 4 (2012), 632–649. doi:10.1080/08838151.2012.732135
[57] Yolande Strengers, Jenny Kennedy, Paula Arcari, Larissa Nicholls, and Melissa Gregg. 2019. Protection, productivity and pleasure in the smart home: Emerging expectations and gendered insights from Australian early adopters. In *ACM Conference on Human Factors in Computing Systems (CHI).* Association for Computing Machinery, 645:1–645:13. doi:10.1145/3290605.3300875
[58] Yolande Strengers and Larissa Nicholls. 2017. Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond. *Energy Research & Social Science* 32 (2017), 86–93. doi:10.1016/j.erss.2017.02.008
[59] Kaiwen Sun, Jingjie Li, Yixin Zou, Jenny Radesky, Christopher Brooks, and Florian Schaub. 2024. Unfulfilled Promises of Child Safety and Privacy: Portrayals and Use of Children in Smart Home Marketing. *Proceedings of the ACM on Human-Computer Interaction* 8, CSCW1 (2024). doi:10.1145/3637422
[60] Kaiwen Sun, Carlo Sugatan, Tanisha Afnan, Hayley Simon, Susan A Gelman, Jenny Radesky, and Florian Schaub. 2021. "They See You're a Girl if You Pick a Pink Robot with a Skirt": A Qualitative Study of How Children Conceptualize Data Processing and Digital Privacy Risks. In *ACM Conference on Human Factors in Computing Systems (CHI).* Association for Computing Machinery, 687:1–687:34. doi:10.1145/3411764.3445333
[61] Kaiwen Sun, Yixin Zou, Jenny Radesky, Christopher Brooks, and Florian Schaub. 2021. Child Safety in the Smart Home: Parents' Perceptions, Needs, and Mitigation Strategies. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW2 (2021), 1–41. doi:10.1145/3479858
[62] Christian Powell Sundquist. 2023. Surveillance Normalization. *Harv. CR-CLL Rev.* 58 (2023), 117.
[63] David Tolfree and Martin Woodhead. 1999. Tapping a key resource. *Early Childhood Matters* 91, 1 (1999), 19–23. https://bibalex.org/baifa/Attachment/Documents/124583.pdf
[64] Sarah Turner, Nandita Pattnaik, Jason RC Nurse, and Shujun Li. 2022. " You Just Assume It Is In There, I Guess": Understanding UK Families' Application and Knowledge of Smart Home Cyber Security. *Proceedings of the ACM on Human-Computer Interaction* 6, CSCW2 (2022), 1–34. doi:10.1145/3555159
[65] Blase Ur, Jaeyeon Jung, and Stuart Schechter. 2014. Intruders versus intrusiveness: teens' and parents' perspectives on home-entryway surveillance. In *ACM International Joint Conference on Pervasive and Ubiquitous Computing.* Association for Computing Machinery, 129–139. doi:10.1145/2632048.2632107
[66] Lev Semenovich Vygotsky and Michael Cole. 1978. *Mind in society: Development of higher psychological processes.* Harvard university press. https://home.fau.edu/musgrove/web/vygotsky1978.pdf
[67] Carol Simon Weinstein and Thomas G David. 1987. *Spaces for children: The built environment and child development.* Springer. doi:10.1007/978-1-4684-5227-3
[68] Charlie Wilson, Tom Hargreaves, and Richard Hauxwell-Baldwin. 2015. Smart homes and their users: a systematic analysis and key challenges. *Personal and Ubiquitous Computing* 19, 2 (2015), 463–476. doi:10.1007/s00779-014-0813-0
[69] Charlie Wilson, Tom Hargreaves, and Richard Hauxwell-Baldwin. 2017. Benefits and risks of smart home technologies. *Energy Policy* 103 (2017), 72–83. doi:10.1016/j.enpol.2016.12.047
[70] Pamela Wisniewski, Arup Kumar Ghosh, Heng Xu, Mary Beth Rosson, and John M Carroll. 2017. Parental Control vs. Teen Self-Regulation: Is there a middle ground for mobile online safety?. In *ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW).* Association for Computing Machinery, 51–69. doi:10.1145/2998181.2998352
[71] Pamela Wisniewski, Haiyan Jia, Heng Xu, Mary Beth Rosson, and John M Carroll. 2015. "Preventative" vs. "Reactive:" How Parental Mediation Influences Teens' Social Media Privacy Behaviors. In *ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW).* Association for Computing Machinery, 302–316. doi:10.1145/2675133.2675293
[72] Richmond Y. Wong, Jason Caleb Valdez, Ashten Alexander, Ariel Chiang, Olivia Quesada, and James Pierce. 2023. Broadening Privacy and Surveillance: Eliciting Interconnected Values with a Scenarios Workbook on Smart Home Cameras. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference* (Pittsburgh, PA, USA) *(DIS '23).* Association for Computing Machinery, New York, NY, USA, 1093–1113. doi:10.1145/3563657.3596012
[73] Yaxing Yao, Justin Reed Basdeo, Smirity Kaushik, and Yang Wang. 2019. Defending my castle: A co-design study of privacy mechanisms for smart homes. In *ACM Conference on Human Factors in Computing Systems (CHI).* Association for Computing Machinery, 198:1–198:12. doi:10.1145/3290605.3300428
[74] Yuan Yao, Li Huang, Yi He, Zhijun Ma, Xuhai Xu, and Haipeng Mi. 2023. Reviewing and reflecting on smart home research from the human-centered perspective. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems.* 1–21. doi:10.1145/3544548.3580842
[75] Eric Zeng, Shrirang Mare, and Franziska Roesner. 2017. End user security and privacy concerns with smart homes. In *Symposium on Usable Privacy and Security (SOUPS).* USENIX Association, USA, 65–80. https://www.usenix.org/system/files/conference/soups2017/soups2017-zeng.pdf
[76] Eric Zeng and Franziska Roesner. 2019. Understanding and improving security and privacy in multi-user smart homes: a design exploration and in-home user study. In *USENIX Security Symposium.* USENIX Association, USA, 159–176. https://www.usenix.org/system/files/sec19-zeng.pdf
[77] Shoshana Zuboff. 2019. *The age of surveillance capitalism: The fight for a human future at the new frontier of power.* Profile books.

A Interview Protocol

Warm-up questions

- First, I am curious to hear about how you would define smart home technologies?
- Based on the initial survey, you mentioned you have [insert provided types of smart home devices], how's your experiences with these smart home technologies? (e.g., how long have you been using them, and what do you use them for.)

Parents' description of children

- Who lives at home with you?
- In this study, we are going to focus on the experiences of your child [child's name.] Could you describe your child's personality in five words or phrases? (Since each family will have one participating child, so the interview will focus on the parent and the one participating child)
  - What is it about [child's name] that makes you say that?
- Next, I want to learn about your relationship with your child now. Please focus on your relationship with your child, take a moment to think about when you and your child are together. I'd like you to choose some descriptive words or phrases to reflect your relationship with your child. Like describe how it feels when you are together. And examples that illustrate these words you choose.
  - What are some things that you love to do together?
  - What types of activities help you feel connected with [child]?

Families experiences with smart home technologies

- Based on the initial survey, you mentioned your child has access or uses [insert provided types of smart home devices]. Could you explain how your child controls, accesses or uses [insert provided types of smart home devices]?
  - Do you have rules/reminder/instruction/explaination about what [child] can and cannot do with [smart home device]?
- What are some of your family routines that involve using smart home technologies?
  - What are some of your favorite routines, and how do smart home technologies play a role in it? Especially the routines involving your child(ren)?
- What kind of smart home devices/experiences make children feel safe/happy/want to be a part of?
- Can you tell me a time when you feel like using a smart home supporting your relationships and interactions with families? Like it helps facilitate family interactions?
- What kind of smart home devices/experiences support children's involvement and participation in the smart home?
- What kind of smart home devices/experiences make children feel scared/annoyed/irritated/want to avoid?
- Can you tell me a time when you feel like using smart home technologies disrupt your relationships and interactions with families? Disruption by smart home technologies in terms of
  - Parents and children have different needs or preferences of certain smart home technologies or experiences?
  - Parents and children have different ideas of how to use certain smart home technologies?
  - Certain smart home technologies create more tensions around what parents see as protection/safety and children see as exploration?
- What kind of smart home devices/experiences make children feel like they don't have a say so children would argue/bargain/negotiate with parents to gain their place?
  - How do you respond in such situations?

Closing questions

- Are there any questions you expected me to ask?
- Is there anything else you want to tell me about your children and your families' smart home experiences?

B Home Visit: Child-led Tour Script

Instructions for Parent

After child assent is completed, the child will lead a smart home tour while parents will keep our company. To the parent, [parent's name] please let [CHILD] lead the tour and respond to the questions on their own, without your guidance. You're welcome to observe, but please don't help or explain anything to your child. I will ask you clarifying questions toward the end.

Child-led Tour Beginning

Hi [child's name], I am so excited to go on a tour with you. You will show me the places in your home that have smart home technologies you often use. I will ask you questions like when and how you use them, whether you can control them, and whether you like them or not.

During the tour

Note: the child might take the researcher to tour different home spaces such as the entryway, the living/family room, the kid's room. We might see different smart home technologies, especially that parents already mentioned what smart home devices they have during the parental interview:

For each particular smart home device the child points out, the researcher can ask:

- Ask the child to show how they use a smart home device.
- Do you know why your parent would let you have a [device]?
- How do you use/control it? (ask the child to show me how to use it)
- Is this smart home device/experience a part of your daily routine?
- How often do you use it? Do you use it everyday? How do you like using it?
- What do you think about it? What do you like about it? What do you dislike about it?
- Are there other ways you could control it? Like through voice control, apps, automations?
- Do you share this technology/device with your parents/siblings?
- Are there any rules about using this technology/device?
- Do you remember a time that there was a problem using this technology/device?

After the tour

The researcher will ask clarifying followup questions as needed.

- What makes a technology smart?
- Question about family: What do you like to do as a family?
- What type of family activity makes you feel closer together? Does it have anything to do with technology?
- What's your favorite part during the day? How is that related to technology?
- What's your favorite spot at home? Why?
- What kind of technology makes you feel safe/happy/want to be a part of? (ask separately)
- What kind of technology makes you feel uncomfortable/unhappy/don't want to be a part of? (ask separately)

These questions may include whether and how children share particular smart home experiences with parents, the smart home rules, any parent-child conflicting moments (if applicable), and their responses.

C Exit Interview Protocol

C.1 [Warm-up Questions]

This is the last step of our study! Thank you so much for making it this far! Today we will be talking about the design workbook you and [child name] worked on together! To begin with, I'd like to ask you and [child name] to talk about your overall experience of the workbook, what parts of the workbook you liked, you didn't like, and why. [child name] could you start first, then I will ask [parent].

- How did you feel when you were doing the workbook? Was it fun, hard, or something else?
- **To Parent:** What are your observations of child's attitude, behavior, and response to the workbook?

C.2 [In-depth discussion of the workbook content]

- To the child: Let's look through the workbook together! Can you show me your answers and tell me about them? (I'll listen carefully!) [let the child explain answers]
- What do you think might impact parent and child relationships? Make parents/kids work better together?
- Look at the pictures in the workbook. What's good or not-so-good about the story it shows?
- What do you think of Smarty?
- There are 7 families in the workbook. Which one do you like the best?
- Do any of the families feel like they're a bit like your own?

C.3 [In-depth discussion of the workbook format]

- Did you find anything new or surprising about smart home stuff while working on the workbook?
- **To both parent and child:** Do you remember an activity you liked the most? What about one you didn't like? Why?
- **To both parent and child:** Has doing this workbook changed how you feel about smart home things?
- **To both parent and child:** Did the workbook make you think differently about how smart home technologies could work for kids?
- **To both parent and child:** How can we make the workbook more fun or helpful for kids?
- **To both parent and child:** Are there any other family members involved in any of the activities or discussions? Do they have any comments on their experiences?
- **To parent:** What do you think is good or not-so-good about the illustrated scenarios?
- **To parent:** How did the workbook help (or not help) you and your child talk about smart home technologies?
- **To parent:** Do you see any cool ideas for how smart home technologies could be made for kids in the future?
- **To parent:** Has other family members commented on the workbook? Or were you involving other family members?
- **To parent:** How do you like the overall workbook format as a tool to reflect/discuss your ideas about smart home technologies? What works for you and [child name], what didn't work, and why? What do you think might impact parent and child relationships? How has the book got you thinking about tech use and family relationships/interactions mediated/supported by these devices?
- **To both parent and child:** Has doing this workbook changed how you feel about smart home stuff?
- **To both parent and child:** What might be other things (e.g., content, topics, format) we could include to make this workbook better? Is there anything else we should add to the workbook to make it more fun or helpful?
- **To both parent and child:** Generally when you think of smart home technologies, you don't always think of children immediately as the primary users. Part of the goal of the workbook is to get families to think about how smart home technologies could be designed for children's involvement and participation. For you [parent], I wonder what you see as the potential value and opportunities here for future smart home technologies designed for children?
- **To both parent and child:** Has the workbook made you think differently about smart homes and children?

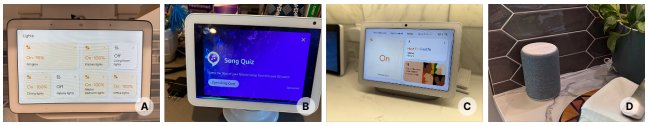

Figure 12: Smart displays and speakers for families' shared use.

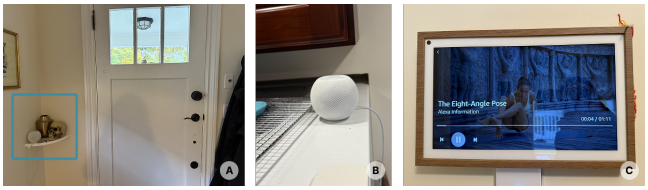

Figure 13: Multiple smart speakers and displays in family 3: an Apple HomePod speaker right by the front door (A), a second one above the fridge in the kitchen (B), and an Amazon Echo smart display placed in the dining area (C).

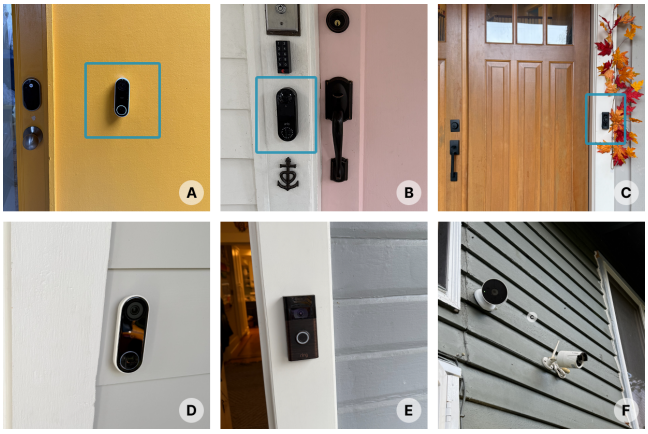

Figure 8: Entryway monitoring cameras and smart locks. Most cameras are built into the smart doorbells.

Figure 9: An example of the smart lock, two views from inside (A) and outside (B) of the door, that can be controlled by an app (C).

Figure 10: Different types of smart thermostats.

Figure 11: Robot vacuums and mops.

D Photos of smart home devices in participants' families