

Supporting Long-Term HRI Through Shared Family Routines

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ABSTRACT

Technical and practical challenges in human-robot interaction (HRI) research often involve facilitating sustained long-term interactions, fostering engagement with multiple individuals, and taking place in-the-wild. The home environment embodies all three challenges, as multiple family members regularly engage with technology at home. In our research, we take a family-centered approach to understand, design, and evaluate how social robots can take part in setting and maintaining family routines to support long-term HRI. In our prior work, we conducted participatory design sessions with children and families to understand their preferences for having social robots in their *home*. We then designed interactions for robot-facilitated *routines*. Finally, our future work will include field studies investigating how robot-facilitated routines can support *long-term* engagement in family-robot interactions and facilitate connections.

CCS CONCEPTS

- Human-centered computing → Field studies; Interaction design theory, concepts and paradigms.

KEYWORDS

social robots, long-term, in-home, multi-party, child, family

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1 INTRODUCTION

Long-term interaction [2, 25], adaptation [36], and personalization [17, 24] have long been challenges in human-robot interaction and child-robot interaction. To overcome barriers to successful long-term human-robot interaction, there is a need to take robots out of the laboratory and to the real world where users can naturally interact with robots [19, 35]. Applications of robotic interventions in-the-wild have shown promise of supporting children’s learning [3] and therapy [9] in real-world contexts such as schools [30, 37], hospitals [35], and homes [20]. Furthermore, research in family studies shows that *family routines and rituals* can help improve

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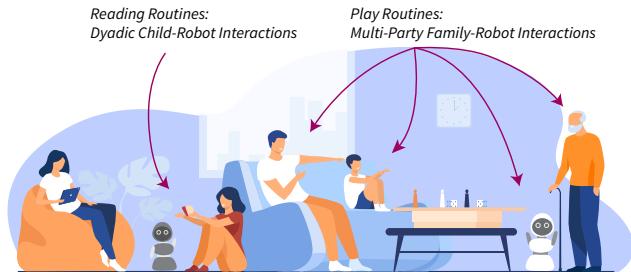


Figure 1: Examples of robot-facilitated family routines.

family relationships and connection-making [12]. They can help children build resilience and buffer stress through major life transitions such as a global pandemic [1], moving to a new city, having parents going through a divorce, or dealing with grief [11].

Such routines emerge, develop, and change in close relation with different kinds of everyday technologies in the home [8, 14]. However, families often experience tensions between the *need for setting* and the *difficulty of maintaining* routines. Technology-mediated solutions such as reminders from a shared family calendar [29, 31] or a verbal notification from a smart assistant [4] can help but are easy to ignore or miss. Social robots, however, are physically embodied agents that can serve the role of a friendly coach that can roam over to a child’s room and provide adaptive and personalized interventions to motivate routines for exercising [15] or cleaning [13]. Robots can convey excitement to help set a new routine for bedtime and sleep hygiene [40] and have consistent engagement with families through verbal, non-verbal, and behavioral interactions to help maintain their routine in the long-term.

In our work, we aim to expand the field’s understanding of these broader challenges for long-term interaction in HRI. To do this, we take a family-centered approach to understand, design, and evaluate robotic systems tailored to support interactions between families and robots. We use participatory research methods [10], conduct field studies at homes, and use the Misty robot [34] platform. Our overarching goal is to demonstrate that *social companion robots embedded into the home can enable long-term interactions through facilitating family routines*. We ask the following research questions:

Completed Work

- (Understand) What are the preferences of families for having a social robot in their home?
- (Design) What are the design considerations for robot-facilitated family routines?

Current and Future Work

- (Evaluate) How can robot-facilitated family routines support long-term engagement in family-robot interactions?

2 UNDERSTAND: FAMILY PREFERENCES FOR IN-HOME SOCIAL ROBOTS

In our prior work [5], we explored families' preferences for an in-home social robot through participatory design sessions. We identified three key insights. First, families expected robots to have two **roles** in the home: a *companion* and an *assistant*. As a companion, the robot should serve as a playmate, reading companion, or confidant. As an assistant, the robot should provide information in daily tasks, such as cooking or doing homework. Second, families expected the robot to be included in **group interactions** and were enthusiastic about having engaging activities with a robot. For example, families expected a playmate robot to be an active participant in family game nights, dance, or sports. However, some parents refuse to use the robot during family dinners. Third, families expressed **privacy concerns** for how a robot should manage sensitive information shared in conversations. Discussions about private and group conversations between members, such as a parent and a child, raised concerns about the robot's unintended capacity to share private information with other members, e.g., a grandparent. Parents sought to have control over the robot without compromising trust with their children. These findings emphasize the need to consider broader factors such as family dynamics, relationships, and characteristics when assessing robot acceptance in the home.

3 DESIGN: ROBOT-FACILITATED ROUTINES

Given these findings, our recent work focused on designing robot-facilitated routines that could support long-term adoption of routines, including (1) care-taking, (2) play, and (3) reading.

Care-Taking Routines. Caring for an interactive agent by comforting [23] or teaching [39] can help form stronger connections and facilitate positive outcomes, including improvements in mental health in adults [23] or support learning gains in children [39]. Inspired by these findings, in our recent work [6], we explored how children chose to incorporate a social robot into their daily routines. In their *morning routines*, children included care activities such as waking up the robot and getting it ready for the day by charging, cleaning, or exercising together. In their *nighttime routines*, children discussed care obligations such as preparing the robot's bed and having shared bedtime activities such as reading or listening to music together. As a part of their *recreation routines*, typically for weekends, children discussed collaborative responsibilities such as preparing and tidying up the area for robot-facilitated games.

Playful Routines. Family playtime with a social robot can be facilitated through “*verbal activities, reading stories, or playing cards*” [21], also echoed in our prior work [5]. To explore this, in our recent work [22], we conducted a technology probe study (e.g., [16]). We delivered a Miko robot [28] to children’s homes and asked them to record their first interactions. Here, we observed children’s experiences of meeting a robot for the first time at their home. We found that children preferred to begin with robot-facilitated activities including dancing together, doing yoga, or playing songs.

Reading Routines. Interactive read-aloud sessions with children can support improved reasoning skills, and build stronger interpersonal skills and connections [26]. Given this motivation, we designed a fully autonomous reading companion robot and deployed it in 16 children’s homes for a study that lasted a month. In

this long-term study [7, 27], children regularly read aloud to the Misty robot [34] as part of their routine. In the reading sessions, the robot responded with interactive comments about the book to promote interest in reading. We observed that family members, such as siblings and parents, were enthusiastic to indirectly take part in the routine between the child-robot pair. We found that most children *adopted* the robot and continued sustained use. However, some *adapted* and changed the interaction mechanics to their own preferences, some were *interrupted* by external disruptions, and some lost interest and *discontinued* using the robot.

4 EVALUATE: LONG-TERM ENGAGEMENT IN FAMILY-ROBOT ROUTINES AT HOME

So far, our work has identified routines that families found important for an in-home robot. Next, we will translate these insights to (1) co-design a family-robot integration plan and (2) evaluate how family-robot shared routines can support long-term engagement. We will conduct a *case study* including three families with at least one child aged 8–12. The studies will take place at family homes.

Family-Robot Integration Plan. Crafting a “Family Media Use Plan” [32] can support open family communication and implementation of consistent rules about media use. Inspired by this, we will work closely with families to craft a *family-robot integration plan (FRIP)* that fits their needs for setting and maintaining routines. For this, we will first collect survey metrics such as family routines inventory [18] and parenting styles [33] as a baseline. These surveys will help identify the frequency, quality, enjoyment, and significance of their routines, the motivators and challenges in setting and maintaining them, and the connections formed around them. Second, we will conduct child-led home tours (e.g., [38]) to allow families to describe current routines and set any boundaries for a robot’s use in their home. Third, we will collect self-reported video diaries capturing families’ engagement in their shared routines. We will then consolidate these insights and propose a personalized FRIP consisting of design requirements developed for family-robot routines. Families will have the opportunity to customize their FRIP through iterative co-design sessions. Finally, we will translate these design insights to develop interactions for an autonomous in-home companion robot that will help set and maintain family routines to sustain long-term use. We will seek feedback from families regarding the robot’s role in joining the family dynamic.

Long-Term Evaluation. To evaluate the effectiveness of this integration plan, we will conduct a long-term field study with each family. The FRIP will help determine the logistics of the deployment (e.g., duration) as well as the robot features and behaviors. Within each family, we will measure the robot’s ability to support long-term interactions through: (1) *behavioral metrics* capturing changes in the frequency of family members’ engagement in shared routines, identified through interaction logs, and (2) *subjective metrics* to identify motivators and challenges in setting and maintaining robot-facilitated routines, collected through weekly surveys and semi-structured interviews, and (3) pre-test and post-test *comparisons* to evaluate the effectiveness of the intervention.

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REFERENCES

[1] Carolyn R Bates, Laura M Nicholson, Elizabeth M Rea, Hannah A Hagy, and Amy M Bohnert. 2021. Life interrupted: Family routines buffer stress during the COVID-19 pandemic. *Journal of Child and Family Studies* 30, 11 (2021), 2641–2651.

[2] Paul Baxter, Tony Belpaeme, Lola Canamero, Piero Cosi, Yiannis Demiris, Valentin Enescu, A Hiolle, I Kruijff-Korbayova, R Looije, M Nalin, et al. 2011. Long-term human-robot interaction with young users. In *IEEE/ACM human-robot interaction 2011 conference (robots with children workshop)*, Vol. 80. IEEE/ACM.

[3] Tony Belpaeme, James Kennedy, Aditi Ramachandran, Brian Scassellati, and Fumihide Tanaka. 2018. Social robots for education: A review. *Science robotics* 3, 21 (2018), eaat5954.

[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 *Proceedings of the 2020 CHI conference on human factors in computing systems*. 1–13.

[5] Bengisu Cagiltay, Hui-Ru Ho, Joseph E Michaelis, and Bilge Mutlu. 2020. Investigating family perceptions and design preferences for an in-home robot. In *Proceedings of the interaction design and children conference*. 229–242.

[6] Bengisu Cagiltay, Joseph Michaelis, Sarah Sebo, and Bilge Mutlu. 2022. Exploring Children's Preferences for Taking Care of a Social Robot. In *Interaction Design and Children*. 382–388.

[7] Bengisu Cagiltay, Nathan Thomas White, Rabia Ibtasar, Bilge Mutlu, and Joseph Michaelis. 2022. Understanding Factors that Shape Children's Long Term Engagement with an In-Home Learning Companion Robot. In *Interaction Design and Children*. 362–373.

[8] Andy Crabtree and Tom Rodden. 2004. Domestic routines and design for the home. *Computer Supported Cooperative Work* 13, 2 (2004), 191–220.

[9] Julia Dawe, Craig Sutherland, Alex Barco, and Elizabeth Broadbent. 2019. Can social robots help children in healthcare contexts? A scoping review. *BMJ paediatrics open* 3, 1 (2019).

[10] Alison Druin. 2002. The role of children in the design of new technology. *Behaviour and information technology* 21, 1 (2002), 1–25.

[11] Patrice L Engle, Sarah Castle, and Purnima Menon. 1996. Child development: Vulnerability and resilience. *Social science & medicine* 43, 5 (1996), 621–635.

[12] Barbara H Fiese. 2006. *Family routines and rituals*. Yale University Press.

[13] Julia Fink, Séverin Lemaignan, Pierre Dillenbourg, Philippe Rétornaz, Florian Vaussard, Alain Berthoud, Francesco Mondada, Florian Wille, and Karmen Franićović. 2014. Which robot behavior can motivate children to tidy up their toys? design and evaluation of "Ranger". In *2014 9th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 439–446.

[14] Kirsten Gram-Hanssen. 2008. Consuming technologies—developing routines. *Journal of Cleaner Production* 16, 11 (2008), 1181–1189.

[15] Arzu Gunesu and Bert Arnrich. 2017. Socially assistive child-robot interaction in physical exercise coaching. In *2017 26th IEEE international symposium on robot and human interactive communication (RO-MAN)*. IEEE, 670–675.

[16] Hilary Hutchinson, Wendy Mackay, Bo Westerlund, Benjamin B Bederson, Alison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Stéphane Conversy, Helen Evans, Heiko Hansen, et al. 2003. Technology probes: inspiring design for and with families. In *Proceedings of the SIGCHI conference on Human factors in computing systems*. 17–24.

[17] Bahar Irfan, Aditi Ramachandran, Samuel Spaulding, Dylan F Glas, Iolanda Leite, and Kheng Lee Koay. 2019. Personalization in long-term human-robot interaction. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 685–686.

[18] Eric W Jensen, Sherman A James, W Thomas Boyce, and Sue A Hartnett. 1983. The family routines inventory: Development and validation. *Social Science & Medicine* 17, 4 (1983), 201–211.

[19] Malte Jung and Pamela Hinds. 2018. Robots in the wild: A time for more robust theories of human-robot interaction. , 5 pages.

[20] Cory D Kidd and Cynthia Breazeal. 2008. Robots at home: Understanding long-term human-robot interaction. In *2008 IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, 3230–3235.

[21] SunKyung Kim, Masakazu Hirokawa, Atsushi Funahashi, and Kenji Suzuki. 2022. What Can We Do with a Robot for Family Playtime?. In *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 847–849.

[22] Christine P Lee, Bengisu Cagiltay, and Bilge Mutlu. 2022. The unboxing experience: Exploration and design of initial interactions between children and social robots. In *Proceedings of the 2022 CHI conference on human factors in computing systems*. 1–14.

[23] Minha Lee, Sander Ackermans, Nena Van As, Hanwen Chang, Enzo Lucas, and Wijnand IJsselsteijn. 2019. Caring for Vincent: a chatbot for self-compassion. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[24] Min Kyung Lee, Jodi Forlizzi, Sara Kiesler, Paul Rybski, John Antanitis, and Sarun Savetsila. 2012. Personalization in HRI: A longitudinal field experiment. In *Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction*. 319–326.

[25] Iolanda Leite, Carlos Martinho, and Ana Paiva. 2013. Social robots for long-term interaction: a survey. *International Journal of Social Robotics* 5 (2013), 291–308.

[26] Sandra Lennox. 2013. Interactive read-alouds—An avenue for enhancing children's language for thinking and understanding: A review of recent research. *Early Childhood Education Journal* 41 (2013), 381–389.

[27] Joseph E Michaelis, Bengisu Cagiltay, Rabia Ibtasar, and Bilge Mutlu. 2023. "Off Script:" Design Opportunities Emerging from Long-Term Social Robot Interactions In-the-Wild. In *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*. 378–387.

[28] Miko. 2023. Miko 2 Robot. <https://miko.ai/>

[29] Carman Neustaeder, AJ Bernheim Brush, and Saul Greenberg. 2009. The calendar is crucial: Coordination and awareness through the family calendar. *ACM Transactions on Computer-Human Interaction (TOCHI)* 16, 1 (2009), 1–48.

[30] Kwangmyung Oh and Myung-Suk Kim. 2010. Social attributes of robotic products: observations of child-robot interactions in a school environment. *International Journal of Design* 4, 1 (2010), 45–55.

[31] Catherine Plaisant, Aaron Clamage, Hilary Browne Hutchinson, Benjamin B Bederson, and Allison Druin. 2006. Shared family calendars: Promoting symmetry and accessibility. *ACM Transactions on Computer-Human Interaction (TOCHI)* 13, 3 (2006), 313–346.

[32] Yolanda Linda Reid Chassiakos, Jenny Radesky, Dimitri Christakis, Megan A Moreno, Corinn Cross, David Hill, Nusheen Ameenuddin, Jeffrey Hutchinson, Alanna Levine, Rhea Boyd, et al. 2016. Children and adolescents and digital media. *Pediatrics* 138, 5 (2016).

[33] Clyde C Robinson, Barbara Mandleco, S Frost Olsen, and Craig H Hart. 2001. The parenting styles and dimensions questionnaire (PSDQ). *Handbook of family measurement techniques* 3 (2001), 319–321.

[34] Furhat Robotics. 2023. Misty II Robot. <https://www.mistyrobotics.com/>

[35] Raquel Ros, Marco Nalin, Rachel Wood, Paul Baxter, Rosemarijn Looije, Yannis Demiris, Tony Belpaeme, Alessio Giusti, and Clara Pozzi. 2011. Child-robot interaction in the wild: advice to the aspiring experimenter. In *Proceedings of the 13th international conference on multimodal interfaces*. 335–342.

[36] Silvia Rossi, François Ferland, and Adriana Tapus. 2017. User profiling and behavioral adaptation for HRI: A survey. *Pattern Recognition Letters* 99 (2017), 3–12.

[37] Sofia Serholt, Lena Pareto, Sara Ekström, and Sara Ljungblad. 2020. Trouble and repair in child-robot interaction: A study of complex interactions with a robot tutee in a primary school classroom. *Frontiers in Robotics and AI* 7 (2020), 46.

[38] Kaiwen Sun. 2023. A Smart Home for 'Us': Understanding and Designing a Parent-Child Engagement Mechanism for Child Access and Participation in the Smart Home. In *Proceedings of the 22nd Annual ACM Interaction Design and Children Conference* (Chicago, IL, USA) (IDC '23). Association for Computing Machinery, New York, NY, USA. <https://doi.org/10.1145/3585088.3593927>

[39] Fumihide Tanaka and Shizuko Matsuzoe. 2012. Children teach a care-receiving robot to promote their learning: Field experiments in a classroom for vocabulary learning. *Journal of Human-Robot Interaction* 1, 1 (2012), 78–95.

[40] Kelly LA van Bindsbergen, Hinke van der Hoek, Marloes van Gorp, Mike EU Ligthart, Koen V Hindriks, Mark A Neerincx, Tanja Alderliesten, Peter AN Bosman, Johannes HM Merks, Martha A Grootenhuis, et al. 2022. Interactive education on sleep hygiene with a social robot at a pediatric oncology outpatient clinic: feasibility, experiences, and preliminary effectiveness. *Cancers* 14, 15 (2022), 3792.