Facilitation of Learning Activities for Children by Voice-User Interfaces in the Home

**Elizabeth Skora**  
Human Development and Family Studies  
 University of Wisconsin-Madison  
Madison, WI USA  
 [eskora@wisc.edu](mailto:eskora@wisc.edu)

**Sajal Jain**  
 Computer Science  
University of Wisconsin-Madison  
Madison, WI USA  
 [sjain@wisc.edu](mailto:sjain@wisc.edu)

**Karan Dharni**  
Computer Science  
University of Wisconsin-Madison  
Madison, WI USA  
 [dharni@wisc.edu](mailto:dharni@wisc.edu)

ABSTRACT

Voice-user interfaces (VUIs) are widely present in homes, and manufacturers claim that these devices offer a variety of learning opportunities for children. The current work explored caregiver perceptions about their child’s behaviors with VUIs to understand what learning activities VUIs facilitate. Caregivers completed an open-ended questionnaire assessing their perceptions about VUIs safety, reliability, purpose, and value for use with children. A subset of participants completed daily diary surveys about their child’s VUI interactions. Results suggest that while caregivers view VUIs as having the potential to facilitate learning, children infrequently engage with the VUI for learning beyond playing songs. It is important to understand children’s daily activities with VUIs, as well as caregiver perceptions, to verify claims about the educational value of VUIs made by manufacturers and to predict whether VUIs can aid in learning across childhood.

KEYWORDS

Children; Learning activities; Voice-user interfaces

1 INTRODUCTION

Recent reports show that 18% of American homes have a smart speaker with a voice-user interface (VUI), and some of these devices specifically advertise supporting children's learning [1]. However, there is a great deal of uncertainty about the role of these devices for children in the home. This work considered children’s interactions with VUIs in the home for learning. There are three key areas of study that our work connects with. Firstly, we identified the current state of research concerning VUIs (e.g., Amazon Alexa) in the home. This includes the interactions of children and families with VUIs, as well as their perceptions about the VUI’s purpose and competencies. Secondly, we considered the ways that parents’ perceptions of technology influence children’s use. Finally, we addressed an overarching perspective on children’s technology use in the home, especially for educational activities. Through review of these three key content areas we identify an existing gap and formulate our research questions to consider what type of learning events VUIs in the home facilitate for children, and how children’s use is influenced by parent perceptions.

To categorize the facilitation of learning activities by VUIs, we conducted a cross-sectional study of caregiver opinions about and children’s actual use of VUIs in the home. Our study involved open-ended questionnaires to assess perceptions and daily diaries to measure behaviours. We systematically analysed our data using both qualitative methods through grounded theory and quantitative methods using descriptive statistics and correlations.

In the following sections, we present information on related work. Subsequently, we present an account of our methodology, as well as a detailed report of our quantitative and qualitative results. Finally, we conclude by summarizing our results and suggesting the implications stemming from this research.

2  RELATED WORK

Voice-user interfaces in the home are considered user-friendly devices that offer promise for a variety of uses, including entertainment, information seeking, assistance with everyday tasks, and home control [2]. VUI devices are most frequently used by adults for checking the weather forecast, playing music, and controlling other devices in the home [3]. Past work has also focused on how VUIs become embedded in the everyday complex life of families, including involvement within conversations [4]. However, it is less clear how children are using these devices in their daily lives. It is important to understand the roles VUIs play in the lives of children at home, as well as caregiver perceptions of the devices, to predict whether VUIs can aid in child development [5].

Users’ perceptions of VUIs play a large role in determining not only the quality and content of their interactions, but also their trust in the device. A key aspect of user perceptions is their level of agent personification. Prior research found that children build relationships with robots similarly to how they build relationships with people [6], but that age and prior experience influence children’s ability to reason about the nature of a robotic companion [7]. However, it remains unclear which other factors may contribute to children’s perception of the agent. A study of Echo device user reviews on Amazon.com concluded that greater device personification was associated with more sociable uses for the device and greater overall user satisfaction [8]. Similarly, research suggests that children interact with voice interfaces more when they personify the agent [9]. By conducting in-depth studies with a small number of children, researchers have determined that children conceptualize VUIs as a complete system with advanced intelligence [10].

Despite beginning to identify how children perceive VUIs, prior work does not answer important questions about the role of VUIs for children’s learning. A study of children ages of 3-10 revealed that children believe they can both teach and learn from VUIs [11]. In a study of 406 families conducted in Australia, most parents had positive views about the educational value of technology [12]. A similar study involving families in the United States showed that most parents believe technology has a positive influence on language development in their children [13]. This suggests that VUIs in the home could serve as valuable learning companions for young children, but this potential may be gated by caregiver perceptions. Parents report privacy concerns and feel uncomfortable when their children interact with a smart voice-interface device without their supervision [14]. Furthermore, caregivers express concern about how interacting with VUIs from a young age may influence children’s level of social awareness [15].

In a study involving 14 families, it was shown that parents' inclination towards using technology plays a role in deciding the technological resources present in a child's life [16]. Similarly, there is an association between parents’ own experiences of technology in the workplace or in educational settings and the technological opportunities they offered their children [17]. This direct reflection of parent perceptions about technology on children’s use highlights a knowledge gap in understanding caregiver opinions about VUIs, and how this opinion influences their children’s interactions with VUIs in the home for learning.

Digital media devices in the home are frequently advertised as educational tools for children [18]. Catalysed by the introduction of iPad in 2010, digital technology in the home has become increasingly accessible to younger children who lack the motor skills to use more advanced learning technology. Recent advancements in VUIs in the home make digital technology accessible to children as soon as they can speak. While the educational potential of VUIs remains unexplored, prior research suggests that in-home digital technology offers increasingly abundant learning opportunities for children.

The most widely used digital technology for children in the home is touch-screen tablets (e.g., iPad, Kindle) which enable caregivers and children to download educational applications (apps) and games. These interfaces are easy for young children to navigate, which has led to popularity with preschool-aged children. Evidence suggests that tablets can aid development for young children through interactive games that offer educational instruction [19, 20]. Beyond direct instruction, children’s digital media devices also offer several affordances for learning through play [21]. Similarly, VUIs advertise offering a variety of game-based, direct instruction, and exploratory play learning activities for children [22].

While it has been established that voice-user interfaces are present in homes and widely used by both caregivers and children, it remains unclear whether these devices facilitate the learning activities they claim to offer. This focus is guided by claims made by the Amazon Alexa Echo Dot, that the device facilitates learning activities in the form of singing songs, reading audiobooks and telling stories, playing games, suggesting educational activities, and answering questions [22]. There is also a gap in understanding how children use VUIs and whether their interactions and perceptions are associated with caregiver perceptions**.** Based on prior work and identified knowledge gap we define two hypotheses:

H1: Social agents are advertised as learning tools but are not used as such by children and families. H2: Children’s use and perception of social agents is associated with caregiver’s perceptions about the device.

3  METHOD

3.1 Study Setting and Population

This work considers the experiences of caregivers and their children in the home when interacting with a VUI. In order to test advertising claims made by VUI manufacturers, the specific participant population consisted of caregivers and their children between the ages of birth to thirteen years. All study activities took place in the family’s home. Participants included caregivers (*N* = 49, *M* = 36.30 years) of children between the ages of 0-13 (*M* = 6.08 years). Of all the participants 59.18% had Alexa, 20.4% had Google Home, 4.0% had Siri and 16.32% didn’t own a social agent.

3.2 Data Collection Methods

Data collection for this study took place in two phases. In the first phase, open-ended exploratory questionnaires were distributed to caregivers online via Qualtrics software. The questionnaire link was distributed on social networks including Facebook, LinkedIn, Twitter, Reddit, and local online parenting communities. A subset of caregivers (*N* = 5) were contacted for a follow-up daily diary survey. The daily diary was done for three consecutive days and asked questions about the child’s VUI use that day.  The daily diaries were used to triangulate caregiver responses to the questionnaire with actual behavioural data.

3.3 Materials and Instruments

Both open-ended questionnaires and daily diaries were collected via Qualtrics software. Open-ended questions were asked about VUI device ownership, children’s typical interactions with the VUI, child’s conceptualization of the VUI, quality of VUI responses to the child, learning activities facilitated by the device, and caregiver expectations and comfort level with the device. Specific information was collected about the type of interactions children have with the VUI, who is present while they are interacting, how the VUI responds, and how the children perceive responses. Additionally, questions considered children’s conceptualization of the VUI. The focus was to assess both actual learning activities occurring with the VUI and caregiver perceptions about potential learning activities. Questions were asked about certain domains of knowledge caregivers believe VUIs are particularly capable and incapable of. All responses were recorded by the Qualtrics software and downloaded into Excel CSV format. Daily diaries were also collected via Qualtrics software, with each family having a unique identifier. Diaries asked caregivers whether the child interacted with the VUI that day, how long the interaction lasted, who was present, and the content of the interaction. At the end of the three-day daily diary period, all responses were downloaded into Excel CSV format.

3.4 Data Analysis Methods

Quantitative data was analyzed using the software *R*. Qualitative data from this study was analyzed using a grounded theory approach with the goal of building substantive theory. This iterative process involved identifying open codes within the data, condensing all identified open codes into axial code categories, reviewing categories to determine connecting stories and relationships between them to build a model, and finally abstracting these stories and relationships into formal models through comparative analysis.  All qualitative data analysis was conducted manually in Microsoft Excel, with mind maps designed through the software XMind Zen for further data visualization.

4  RESULTS

4.1 Quantitative Results

*4.1.1 Descriptive Statistics and Correlations*

Before testing hypotheses, preliminary analyses were conducted. Participants rated their comfort level with their child’s device use *(M* = 4.18, *SD* = 1.82), perceived accuracy of the VUI’s responses to their child (*M* = 3.67, *SD* = 0.97), awareness of parental controls (*M* = 3.32, *SD* = 0.88), and support for learning use (*M* = 3.89, *SD* = 0.89) on a scale from 1 to 7. When considering correlations, child age was significantly correlated with both caregiver comfort level (r = .40, p < .01) and caregiver accuracy perception (r = .44, p <. 01). Caregiver comfort level was also significantly negatively correlated with caregiver age (r = -.33, p < .05) and positively correlated with caregiver accuracy perception (r = .32, p < 0.05). Furthermore, accuracy perception was correlated with use of parental controls (r = .39, p < .01). Descriptive statistics and correlations are included in the Appendix.

4.2 Qualitative Results

*4.2.1 Open Coding*

The first step in our qualitative analysis consisted of line by line consideration of questionnaire data to identify the key code for each response. Primary, secondary, and tertiary codes were identified when a response included multiple points. In total, 191 unique codes were identified.

*4.2.2 Reliability Analysis*

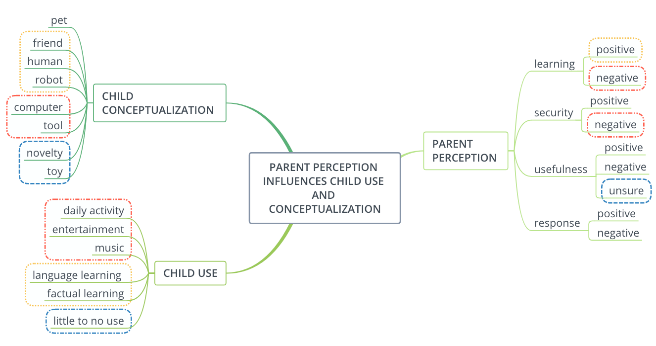
An inter-coder reliability analysis was conducted between the three raters for initial open codes. Cohen’s Kappa revealed a sufficiently high reliability (κ =0.92) between raters.

*4.2.3 Axial Coding*

Concepts were identified from open codes and delineated into circumstances guiding use (e.g., device ownership, caregiver trust of device, caregiver use of parental controls, caregiver perception of potential device uses), actions and interactions (e.g., reported child use of VUI), and consequences (e.g., child perception of agent, caregiver perception of agent’s response to child,). Thirty main categories were abstracted from the data using this method.

*4.2.4 Selective Coding & Model Building*

After categories were extracted from the data and thirty main categories were defined, XMind software was utilized for mind mapping. Depictions of the data revealed relationships between categories, which were formulated into stories within the data. Specifically, these stories and relationships explained children’s activities with and conceptualizations of the VUI, caregiver perceptions of the VUI’s usefulness, features, and security, and factors limiting children’s use. See Figure 1 for a depiction of a mind mapping analysis.

** **Figure 1: The connection between parent perception, child use, and child conceptualization.**

*4.2.5 Comparative Analysis*

By identifying and defining stories and relationships between the thirty main codes, two main stories arose from the data. These main stories were tested within the data through comparison across qualitative questionnaires and daily diary data across different domains (e.g., caregiver age, child age, caregiver device perceptions, child device perceptions). The first story highlighted a disparity between children’s actual learning activities and the learning activities that caregivers believed possible. The second story revealed a connection between parent perceptions about the device, child use, and child conceptualization of the device.

*4.2.6 Theory Building*

Finally, after comparing and confirming stories abstracted from the data, a unified model was defined. The high-level paradigm is that while caregivers perceive that VUIs *could* be used for a wide variety of learning activities, their *actual* use is limited primarily to playing music and singing songs. This is influenced by a number of parent, child, and device limiting factors. Specifically, children’s VUI interactions and subsequent conceptualizations of the device are influenced by parent perceptions about the device’s use, safety, and learning potential. Parents who are more supportive of the device’s potential and comfortable with device use have children who use the device for a wider variety of activities and tend toward device personification.

5  CONCLUSION

In summary, while caregivers report a limited variety of actual learning activities facilitated by the VUI in their home, they were highly supportive of potential learning activities that the agent could facilitate for their child. Caregivers who support the potential for VUIs to be used for learning activities have children that both play songs and ask questions of the device, and therefore perceive the device as a robot, friend, or human. This finding aligns with prior work about children’s device personification [9]. Alternatively, caregivers who were resistant to learning use or mistrust the device have children that use the device mainly for playing music or daily activities (e.g., alarms, controlling lights) and perceive the device as a computer, tool, or smartphone. A third group of parents were unfamiliar with device capabilities, and subsequently had children with limited device access who perceive the device as a novelty or toy. While these are general patterns of use, VUI use is ultimately moderated by individual differences in child, parent, and contextual factors. By enhancing knowledge about discrepancies between potential and actual use of VUIs for learning, these findings suggest that VUI designers may benefit from providing training resources about how children can use the device for educational purposes.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Bilge Mutlu and all our participants.

REFERENCES

[1] National Public Radio and Edison Research. 2018. The Smart Audio Report. National Public Media, LLC. Washington, DC.

[2] Aung Pyae and Tapani N. Joelsson. 2018. Investigating the usability and user experiences of voice user interface: a case of Google home smart speaker. In Proceedings of the 20th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct (pp. 127-131). ACM. New York, NY.

[3] Irene Lopatovska, Katrina Rink, Ian Knight, Kieran Raines, Kevin Cosenza, Harriet Williams, Perachya Sorsche, David Hirsch, Qi Li, and Adrianna Martinez. 2018. Talk to me: Exploring user interactions with the Amazon Alexa. Journal of Librarianship and Information Science. 0, 00 (March 2018), 1-14. DOI: [https://doi.org/10.1177/0961000618759414](https://doi.org/10.1177%2F0961000618759414)

[4] Martin Porcheron, Joel E. Fischer, Stuart Reeves, and Sarah Sharples. 2018. Voice Interfaces in Everyday Life. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 640, 12 pages. DOI: <https://doi.org/10.1145/3173574.3174214>

[5] Silvia Lovato and Anne Marie Piper. 2015. "Siri, is this you?": Understanding young children's interactions with voice input systems. In Proceedings of the 14th International Conference on Interaction Design and Children (IDC '15). ACM, New York, NY, USA, 335-338. DOI:<http://dx.doi.org/10.1145/2771839.2771910>

[6] Fumihide Tanaka, Aaron Cicourel, and Javier R. Movellan. 2007. Socialization between toddlers and robots at an early childhood education center. In Proceedings of the National Academy of Sciences. 104, 46 (Sept. 2007), 17954-17958. DOI: <https://doi.org/10.1073/pnas.0707769104>

[7] Peter H Kahn, Batya Friedman, Deanne R Perez-Granados, and Nathan G Freier. 2006. Robotic pets in the lives of preschool children. Interaction Studies 7, 3 (Jan 2006), 405–436. DOI:<https://doi.org/10.1075/is.7.3.13kah>

[8] Amanda Purington, Jessie G. Taft, Shruti Sannon, Natalya N. Bazarova, and Samuel Hardman Taylor. 2017. "Alexa is my new BFF": Social Roles, User Satisfaction, and Personification of the Amazon Echo. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '17). ACM, New York, NY, USA, 2853-2859. DOI: <https://doi-org.ezproxy.library.wisc.edu/10.1145/3027063.3053246>

[9] Svetlana Yarosh, Stryker Thompson, Kathleen Watson, Alice Chase, Ashwin Senthilkumar, Ye Yuan, and A. J. Bernheim Brush. 2018. Children asking questions: speech interface reformulations and personification preferences. In Proceedings of the 17th ACM Conference on Interaction Design and Children (IDC '18). ACM, New York, NY, USA, 300-312. DOI: <https://doi-org.ezproxy.library.wisc.edu/10.1145/3202185.3202207>

[10] Julia Woodward, Zari McFadden, Nicole Shiver, Amir Ben-hayon, Jason C. Yip, and Lisa Anthony. 2018. Using Co-Design to Examine How Children Conceptualize Intelligent Interfaces. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 575, 14 pages. DOI: <https://doi-org.ezproxy.library.wisc.edu/10.1145/3173574.3174149>

[11] 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 (IDC '17). ACM, New York, NY, USA, 595-600. DOI: <https://doi-org.ezproxy.library.wisc.edu/10.1145/3078072.3084330>

[12] Brittany Huber, Kate Highfield, and Jordy Kaufman. 2018. Detailing the digital experience: Parent reports of children's media use in the home learning environment. British Journal of Educational Technology (Aug. 2018), 821-833. DOI: <https://doi.org/10.1111/bjet.12667>

[13] Lindsey E. Hanna. 2016. Parent Perception of Technology on Children’s Language Development. Honors Thesis Capstone. 297. University of New Hampshire, Durham, NH.

[14] Emily McReynolds, Sarah Hubbard, Timothy Lau, Aditya Saraf, Maya Cakmak, and Franziska Roesner. 2017. Toys that Listen: A Study of Parents, Children, and Internet-Connected Toys. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). ACM, New York, NY, USA, 5197-5207. DOI: <https://doi.org/10.1145/3025453.3025735>

[15] Alex Sciuto, Arnita Saini, Jodi Forlizzi, and Jason I. Hong. 2018. "Hey Alexa, What's Up?": A Mixed-Methods Studies of In-Home Conversational Agent Usage. In Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18). ACM, New York, NY, USA, 857-868. DOI: <https://doi.org/10.1145/3196709.3196772>

[16] Lydia Plowman, Olivia Stevenson, Christine Stephen, and Joanna McPake. 2012. Preschool children's learning with technology at home. Comput. Educ. 59, 1 (Aug. 2012), 30-37. DOI:<http://dx.doi.org/10.1016/j.compedu.2011.11.014>

[17] Lydia Plowman, Christine Stephen, and Joanna McPake. 2010. Growing up with technology: Young children learning in a digital world. Routledge, London, UK.

[18] Cynthia Chiong, and Carly Schuler. 2010. Learning: Is there an app for that? Investigations of young children’s usage and learning with mobile devices and apps. The Joan Ganz Cooney Center at Sesame Workshop. New York, NY.

[19] Michelle M. Neumann and Michael M. Neumann. 2017. The use of touch-screen tablets at home and pre-school to foster emergent literacy. Journal of Early Childhood Literacy, 17, 2 (Dec. 2015),  203-220. DOI: [https://doi.org/10.1177/1468798415619773](https://doi.org/10.1177%2F1468798415619773)

[20] Fashina Aladé, Alexis  Lauricella,  Leanne Beaudoin-Ryan, and Ellen Wartella, E. 2016. Measuring with Murray: Touchscreen technology and preschoolers’ STEM learning. Computers in Human Behavior, 62 (Sept. 2016), 433–441. DOI: <https://doi.org/10.1016/j.chb.2016.03.080>

[21] Kelly L. Schmitt, Lisa B. Hurwitz, Laura Sheridan Duel, and Debora L. Nichols Linebarger. 2018. Learning through play: The impact of web-based games on early literacy development. Computers in Human Behavior, 81 (Dec. 2017), 378-389. DOI: <https://doi.org/10.1016/j.chb.2017.12.036>.

[22] Amazon. 2018. Echo Dot Kids Edition. Video. (25 April 2018). Retrieved October 2, 2018 from https://www.youtube.com/watch?v=jNdZAgij-K0 [Accessed 4 Oct. 2018].

APPENDIX

**Table 1.**

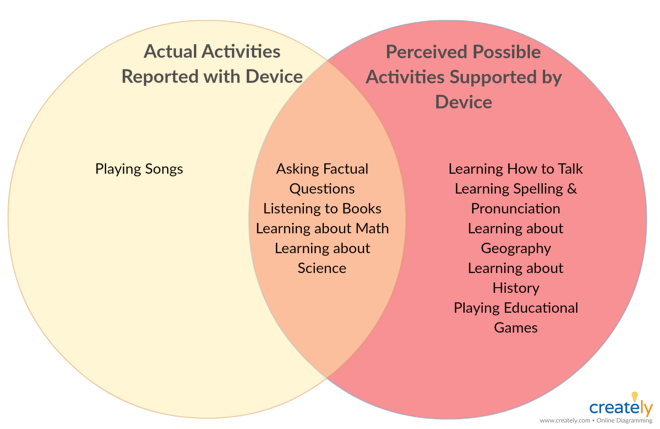
**Descriptive Statistics and Correlations**

****

**Table 2.**

**Parent Perceptions Paired with Child Use Behaviors**





**Figure 2. Comparison of actual and possible learning uses**