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ARTICLE

Talking with machines: Can conversational technologies serve as children's social partners?

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Abstract

Back-and-forth conversations with others are vital for children's development in the early years. While children's conversation partners have traditionally been their parents, teachers, and peers, recent advances in artificial intelligence have led to the introduction of machines that understand human speech and generate natural responses, and thus can engage children in conversations. As these technologies become increasingly ubiquitous in children's lives, questions arise as to how they might affect children's development: How do children interact with, perceive, and learn from conversational technologies? Can these technologies serve as children's social partners? In this article, I detail what we know about these topics and discuss the possible implications of conversational technologies for children's shifting media landscape. I also suggest research agendas that can unpack the complex interplay among children, their social contexts, and conversational technology.

KEYWORDS
artificial intelligence, children's media, conversation, social interaction

Talking with others is important for children's development. Back-and-forth conversations with parents, siblings, teachers, and peers help children develop their language skills as well as their understanding of others and the world around them (Golinkoff et al., 2018). However, many fear that these fruitful conversations are undermined by the prevalence of digital media and technology in children's lives. The development of artificial intelligence has led to the emergence of machines that understand human speech and generate natural responses. In short, these *conversational agents* can now talk with children, and this introduces the possibility of "media as social partners" (Richert et al., 2011, p. 82).

Young children interact with conversational agents through a variety of child-facing media, including the virtual assistants that have become prevalent in many homes (e.g., Apple Siri, Amazon Alexa), as well as voice-enabled tablet apps, social robots, and Internet-connected toys (Druga et al., 2018). While adults' interactions with artificial agents are overwhelmingly task oriented (e.g., asking for specific information; Liao et al., 2018), children's interactions with these agents often contain social elements (Brunick et al., 2016; Calvert, 2021), as illustrated by an anecdote from one of the studies my colleagues and I conducted: A 4-year-old leaned toward a smart speaker and asked playfully, "*Hey Google, what is your favorite princess*?" After Google responded with "*I don't have a favorite princess*," the girl grinned and eagerly announced, "*My favorite princess is Elsa*!" Google responded, "*I will remember that your favorite princess is Elsa*," and the girl burst into laughter that continued for some time.

Although conversational agents are still a relatively new media technology, this anecdote might foreshadow the roles these agents could play in children's lives as the technology becomes increasingly sophisticated and ubiquitous. This possibility raises the question of how machines as conversational partners affect children's development. In this article, I approach this question from the perspectives of developmental psychology and human–computer interaction, synthesizing research on how children interact with, perceive, and learn from conversational agents. Then I discuss the implications of conversational technologies for children's media and

introduce directions for research. Research on this topic has mostly been conducted in the United States with children from families of relatively high socioeconomic status yet who are quite diverse in terms of race/ethnicity; I note exceptions separately.

A DEVELOPMENTAL VIEW OF MACHINES AS SOCIAL PARTNERS

Conversation has been considered a uniquely human form of social interaction (Myllyniemi, 1986). For at least the last several decades, the possibility of forming social relationships with nonhuman entities, particularly with technological objects, has perplexed researchers. In their seminal work, Reeves and Nass (1996) proposed the media equation paradigm, which states that humans tend to automatically apply the same social heuristics used in human interactions to computers even though they know these machines do not have feelings, intentions, or motives. These researchers discovered that the application of social heuristics when interacting with machines was triggered when machines demonstrated certain *social cues* (Nass & Steuer, 1993), namely the humanlike characteristics of *language use, interactivity*, and *speech*. Since the introduction of this theory, technology has evolved to the point that these social cues are now increasingly common and often more convincingly like humans.

Media equation theory originated from research involving young adults. Therefore, applying this theory to research on children's interaction with technology requires additional considerations of children's stages of cognitive development. Some theories suggest that children undergo a series of qualitive shifts in thinking, which restructure the mental schema used to distinguish between living and nonliving beings. One classic example is Piaget's theory that children enter the preoperational stage around age 2, where their intuitive, illogical thinking makes them susceptible to *magical thinking* (Piaget, 1921), and then transition to the next operational stages around ages 6 or 7, when they become more capable of logic and reason.

Alternatively, other researchers argue that children's development of the ability to distinguish living from nonliving beings is a continuous process. This view posits that even young children possess an innate, relatively stable organizing principle that guides how they leverage environmental inputs to refine their conceptual understanding of animacy (Gelman, 1990). Nevertheless, while the nature of progression remains a subject of debate, both schools of thought suggest that early childhood is characterized by an immature yet developing ability to correctly identify the nonhuman nature of artificially intelligent technologies. Thus, the social cues provided by such technologies could lead not only to social responses from children, but also to their categorizing such technologies as living social beings (Melson et al., 2009). This likely positions conversational agents as language partners that can approximate the social processes that propel learning in early childhood.

CHILDREN'S INTERACTIONS WITH CONVERSATIONAL AGENTS

Recent studies have examined how children "talk" with conversational agents in their everyday lives through interviews with parents or children, observations, diaries, or in-home audio recordings. These studies suggest that children engage in two primary forms of interaction with agents: asking the agent questions (child-directed conversation) and answering the agent's questions (agent-directed conversation). For example, one study analyzed audio recordings of 5- and 6-year-olds talking with a smart speaker at home, documenting children asking a range of questions about topics that included science, culture, and practical matters (e.g., weather, directions; Lovato et al., 2019). Children also asked questions about the agent's age and hobbies, as if it were a person. In another study, when 3- to 6-year-olds engaged in storybook reading activities with a conversational agent the researcher designed, the children actively responded to the agent's guiding questions and even shared personal anecdotes (Xu & Warschauer, 2020a). Yet, children's engagement with conversational agents may not always be free of obstacles; voice interfaces sometimes fail to accurately register a child's speech (Beneteau et al., 2019) due in part to child-specific language characteristics such as pitch, verbal intonations, and lack of fluency in speech or immature grammar (Monarca et al., 2020).

In other experimental studies, researchers have begun investigating whether children's engagement with artificial agents rises to the level of interpersonal interaction. In one, 5- to 6-year-olds collaborated with either a smart speaker or an adult experimenter in a treasure hunt, with the children tasked with guiding their respective collaborator (Aeschlimann et al., 2020; children's nationalities were not reported). Children working with the human collaborator supplied more information than did children working with the voice assistant. In another study, 3- to 6-year-olds who were read to either by a smart speaker or an adult experimenter responded similarly (Xu et al., 2021). Both conversational partners engaged children in story-related conversation by asking questions and providing feedback based on a shared script. Children provided longer and more complex responses when conversing with a human, yet the two groups responded to questions with a similar level of accuracy.

Both of the aforementioned experimental studies used smart speakers. These devices were unable to register children's nonverbal expressions (e.g., nodding as "yes"), nor could they demonstrate nonverbal cues (e.g., smiling, eye gaze). By contrast, in the comparison group, children's communications with the human experimenters were not limited by these constraints. Since research

suggests that children are particularly attentive and receptive to their conversation partner's nonverbal contingency (Breazeal et al., 2016), the finding that children are more talkative with partners that can engage in nonverbal interaction is not entirely surprising. Furthermore, these studies are limited by the artificial agents' conversation structure—the initiation-response-feedback model, wherein the interaction resembles disconnected question-and-answer exchanges rather than natural dialogue (Xu et al., 2021). This limits conversational agents' ability to probe children's understanding of or thought process around any given topic. Thus, children's interactions with agents in these studies may differ fundamentally from the kind of child-initiated, interest-driven conversations that progress across extensive back-and-forth interaction (Golinkoff et al., 2018).

HOW DO CHILDREN PERCEIVE CONVERSATIONAL AGENTS?

The research community has long been puzzled by how children perceive conversational agents. To better understand children's perceptions of these agents, researchers have used surveys or semi-structured interviews, as well as drawing tasks for younger participants. For example, one study asked 3- to 6-year-olds to interact with a smart speaker during both free and structured play, and then asked questions to understand whether the children perceived the agent as having biological, psychological, and intelligent properties and whether the agent was a human or a machine (Xu & Warschauer, 2020b). Most children indicated that the conversational agents were sociable and had emotions, and attributed intelligence to them. Nevertheless, while only a small portion of children *classified* the agent as human, a considerable portion of children's drawings depicted the agent as a mixture of both human and mechanical elements that could not be clearly categorized as either human or machine.

When children perceive a conversational agent as more than merely mechanical, researchers can introduce the possibility of building trust with the agent. In one study, researchers directly compared children's trust in conversational agents as sources of information with their trust in humans (Girouard-Hallam & Danovitch, 2022). In these experiments, two groups (4- to 5-year-olds and 7- to 8-year-olds, both of which were predominantly White) were asked to judge the trustworthiness of conflicting information provided by a person during a live video call and a smart speaker secretly controlled by an experimenter. While the study did not find significant differences between children's overall trust in conversational agents compared to humans, children showed greater trust in a conversational agent than in a human for factual information. Yet, when it came to personal information, children showed greater trust in a human than in an agent. This finding was more pronounced in children older than 6 who, the authors suggest, generally have a more comprehensive understanding of the relative strengths and weaknesses of both human knowledge and machine intelligence.

HOW DO CHILDREN LEARN FROM CONVERSATIONAL AGENTS?

Children's conversation with others can benefit their learning in a range of domains, from science and mathematics to literacy and socioemotional skills. Yet, some children have greater access to enriching conversation than their peers, which can contribute to disparities in early learning outcomes that tend to grow over time (Golinkoff et al., 2018). Thus, many in the research community hope that conversational agents can complement the language experiences children have with people. Indeed, a growing number of studies have shown that these artificial agents can provide unique opportunities for conversation (Garg & Sengupta, 2020).

One study suggested that children may learn new linguistic routines while talking with conversational agents and later apply these routines when talking with people (Hiniker et al., 2021). In this study, 5- to 10-year-olds interacted with a smart speaker that sped up its speech whenever children used a particular trigger word (*bungo*) provided by the researchers (the study did not identify children's socioeconomic status or race/ethnicity). The children's parents were also secretly instructed to occasionally slow down their own speech when later talking with their children. Children continued to use the word *bungo* to direct their parents to speak faster. However, because this study used a contrived, nonsensical word as its pragmatic stimulus, it is unclear whether conversational agents can reliably influence children's acquisition of other linguistic routines (Gleason, 1980).

Two experimental studies have suggested that children talking with conversational agents could reap learning benefits comparable to those from conversations with humans. In the first experiment, 4- to 8-year-olds were read a list of information, half of which was provided by a human experimenter and half by a smart speaker conversational agent (Girouard-Hallam & Danovitch, 2022). Then the children were asked to recall the information, and recall accuracy rates were similar in both groups. In the second study, researchers tested the impact of talking with a conversational agent on 3- to 6-year-olds' story comprehension (Xu, Aubele, et al., 2022). Children were read to by either a human experimenter or a smart speaker equipped with a conversational agent designed to serve as a dialogic reading partner. Both the human experimenter and the conversational agent narrated a story to the child, asked questions, and provided responsive feedback. In a comparison of comprehension scores following the readings, dialogic reading with a conversational agent replicated the benefits of dialogic

reading with a human partner. In addition, children who were read to by a conversational agent scored higher on an assessment of comprehension than did children in a third reading condition in which a human experimenter merely read the story without engaging the children in conversation. This suggests that conversation with a reading partner matters more for children's learning than whether the reading partner is human.

Nevertheless, both studies examined learning using assessments immediately after children's single interaction with a conversational agent, which does not address the long-term effects such interactions might have on children's development. In addition, like all other digital technologies, conversational agents and their effects on children's development may be very heterogenous based on the learning contexts. In both studies, children were engaged in structured learning tasks with clear objectives (i.e., comprehending a story, memorizing information), and these learning tasks would probably benefit from the types of question-and-answer opportunities and immediate evaluations provided by conversational agents. Yet, children also learn through less structured activities such as free-form play that have not been incorporated into research on conversational agents since the technologies needed to support these types of interactions are unavailable.

INCORPORATING CONVERSATIONAL AGENTS INTO CHILDREN'S MEDIA

Research on the relation between artificial intelligence and children's development is still in its early phases, but studies point to intriguing opportunities to enrich children's media landscape using conversational agents. While a wide range of children's media could benefit from conversational interactivity, educational television programming seems an ideal area for application (Kirkorian, 2018). Children's television programs are typically observational but many adopt parasocial interaction techniques to create the sense of interactivity (e.g., a character asking a question, pausing, and then reacting as if it heard whatever response the child may have given). These techniques facilitate children's building of enduring *parasocial relationships* with media characters, one-sided, perceptual bonding that can further translate into more optimal learning (Calvert & Richards, 2014; Richards & Calvert, 2017). Parasocial interactions would probably lead more reliably to parasocial relationships if the characters could respond to children contingently, that is, if they could engage in dialogue with each individual child based on their specific response.

Indeed, this notion has been confirmed by two studies that used the Wizard of Oz technique, in which researchers control a media character's responses during its interaction with individual children (Calvert et al., 2019; Peebles et al., 2018). Moreover, in reporting from parents whose children interacted with conversational agents, children could form trusting relationships with conversational agents, and those ties closely resembled the parasocial relationships children commonly have with media characters (Hoffman et al., 2021). These studies provide evidence that favorably positions conversational agents as a potential mechanism for enhancing children's media experiences through contingent interactions with media characters.

PBS KIDS is the brand for most of the children's programming aired by the Public Broadcasting Service in the United States. In a recent study, researchers integrated conversational agents into PBS KIDS children's television shows, allowing children to simultaneously watch their favorite television show and engage in conversation with that show's characters (Xu, Vigil, et al., 2022). The study involved two experiments with 3- to 6-year-olds from a working-class Latino community in the United States. The characters posed questions throughout the episode, listened to and comprehended the child's responses, and replied to the child or provided clues or support when the child struggled to answer the questions. Children who watched the conversational programs scored higher on a posttest assessing their understanding of science concepts introduced in the episode and perceived the character more positively than children who watched the standard, noninteractive version of the TV show (Xu, Vigil, et al., 2022) and children who watched episodes in which the character carried out noncontingent parasocial interactions (Xu et al., 2023). This kind of conversational programming represents one of many ways that conversational technologies can enrich children's media. In the near future, we expect to see more of this kind of conversational interactivity incorporated into a broader range of media products, including e-books, digital games, and smart toys.

RESEARCH AGENDA: TECHNOLOGY, INDIVIDUAL CHILDREN, AND SOCIAL CONTEXTS

The studies I have reviewed speak to the general impacts conversational agents can have on children's development, yet in several areas, our understanding can be deepened and refined. First, researchers may want to examine how the different ways conversational agents speak may affect children differentially. When adults talk to a child, they use a variety of strategies to facilitate their conversation, such as slower rates of speech, exact and paraphrased repetition of content, and pairing of familiar routines with novel vocabulary or concepts. It is worth exploring whether a conversational agent designed to adopt these developmentally appropriate scaffolding strategies would further benefit children's interaction and learning. In addition, research has identified a range of conversational styles that children are likely

to encounter when interacting with people who assume different social roles. For instance, teacher–student talk tends to be more skill centered and institutionalized, while peer talk tends to be more socially oriented, affective, and spontaneous (Zadunaisky Ehrlich, 2011). While this variety in styles of social speech benefits children's development, researchers should consider what social roles and speech styles the conversational agents are designed to assume and how they fit into a child's broader social situation and life.

Second, researchers should consider children's individual differences. Extensive research on children's use of digital technologies (for a review, see Linebarger & Vaala, 2010) indicates that individual children's interactions with and learning from conversational agents are influenced by their unique attributes, such as language abilities, experience with digital media, and cognitive functioning. Yet, the nature and degree of such influence is not straightforward. For example, children with greater language proficiency might be able to converse with artificial agents more smoothly and would thus benefit more from the interactions than would children with lower levels of language proficiency. Children with lower levels of language proficiency might benefit more from language scaffolding, gaining more in terms of learning. Two studies mentioned earlier tested this question (Xu, Aubele, et al., 2022; Xu, Vigil, et al., 2022), yet the studies' relatively small samples rendered the results inconclusive. Furthermore, even though these studies are quite diverse in terms of race/ethnicity, almost all are of typically developing children growing up in households with relatively high socioeconomic status. Researchers should focus on children who are neurodiverse and from a wider range of socioeconomic statuses to intentionally examine the role of children's individual characteristics.

Third, most studies have examined children's individual interactions with conversational agents. Researchers should situate children's interactions with these agents within the broader environmental contexts surrounding their media use. One important area to consider is whether the presence of media with conversational agents influences the quantity and quality of parent–child interactions. For instance, in one study, parents were frequently present and talked with their child when children read an e-book that incorporated a conversational agent, asking them comprehension questions (Zhang et al., 2022). Nevertheless, this study examined parents' joint-engagement behaviors *during* media use in just one session, so it is unclear whether parents' enhanced involvement was because children required more help when using a novel program. Researchers should consider longitudinal in-home studies with a wider range of outcomes, including the role conversational agents play in parents' joint engagement in media use, home language environments, and familial relationships. This approach can shed light on whether and how conversational agents alter broader family dynamics over time (Barr, 2019).

CONCLUSION

Advances in artificial intelligence have led to conversational agents that children readily talk to, trust, and learn from. Children have meaningful interactions with conversational agents, ascribe some humanlike traits to them, and view them as reliable conversational partners. Moreover, interactions with conversational agents have improved children's learning, sometimes as much as have interactions with humans. However, we still have much to learn, and more high-quality research should be done to unpack the complex interplay among children, their social contexts, and technology. Only then will we be able to harness the unique learning experiences conversational agents can provide and ensure that this technology is integrated into children's existing social contexts and relationships in ways that enhance their development.

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CONFLICT OF INTEREST

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