"OK GOOGLE, how tall is the sky?"

How Children Use and Understand Digital Assistants

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June 2022

A thesis submitted to McGill University

In partial fulfilment of the requirements for the degree of

Master of Arts in Educational Psychology

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Abstract

Interactive voice-based digital assistants (DAs) such as Amazon Alexa, Apple Siri and Google Assistant are becoming increasingly commonplace around the world. In western homes particularly, not only are digital assistants a standard feature of the domestic sphere, but commercial DA companies are designing DAs with child-focussed features and designs. This begs the question of the impacts of DA use on young developing children. To investigate this, an inter-disciplinary research project was undertaken. To theorise DA use and child-DA relationships in the home, established theoretical frameworks such as Theory of Mind, Affordance theories, and Parental Mediation Theory are utilised as well as a new theoretical construct, Theory of Artificial Minds, is proposed. The present two studies consider how family DA use, child-DA relationships and parental mediation can be measured and empirically studied. The first study develops measures for family DA use, family information search and child-DA relationships through a survey with parents (n = 50) and brief literature review. The second study uses measures from the first study to investigate family DA use, information search, parental mediation, and child-DA relationships through a large multi-national survey (n = 300). Results from the second study indicate that DAs are used extensively for a variety of tasks, including learning-related uses, with some differentiation observed between Parent and Child DA use. Further, parents largely enable DA use for their children and mediate some DA uses more than others. Lastly, children relate to DAs in distinctive ways and imbue human-like qualities to DAs in some instances. These results contribute to a growing body of knowledge on the impacts of sophisticated Artificial Intelligence technology and promotes informed decision making around technology use in the home.

Keywords: Artificial Intelligence in Education, digital assistants, Theory of Artificial Minds

Abrégé

Les assistants numériques (AN) interactifs basés sur la voix, comme Alexa d'Amazon, Siri chez Apple et Google Assistant, sont de plus en plus courants dans le monde. Dans les foyers occidentaux en particulier, non seulement les assistants numériques sont un élément commun de la sphère domestique, mais les entreprises commerciales de DA conçoivent ces DA avec des caractéristiques et des conceptions plutôt axées sur les enfants. Cela soulève donc la question de l'impact de l'utilisation des DA sur les jeunes enfants en développement. Pour étudier cette question, un projet de recherche interdisciplinaire a été entrepris. Pour théoriser l'utilisation des DA et les relations entre les enfants et les DA à la maison, des cadres théoriques établis tels que la théorie de l'esprit, les théories de l'accessibilité et la théorie de la médiation parentale sont utilisés, et un nouveau concept théorique, la théorie des esprits artificiels, est proposé. Les deux présentes études examinent comment l'utilisation familiale de l'AD, les relations enfant-AD et la médiation parentale peuvent être mesurées et étudiées empiriquement. La première étude développe des mesures pour l'utilisation de l'AD par la famille, la recherche d'informations par la famille et les relations enfant-AD par le biais d'une enquête auprès des parents (n = 50) et d'une brève analyse documentaire. La deuxième étude utilise les mesures de la première étude pour examiner l'utilisation de l'AD par les familles, la recherche d'informations, la médiation parentale et les relations enfant-AD par le biais d'une grande enquête multinationale (n= 300). Les résultats de la deuxième étude indiquent que les assistants numériques sont utilisés de manière intensive pour une variété de tâches, y compris des utilisations liées à l'apprentissage, avec une certaine différenciation observée entre l'utilisation des assistants numériques par les parents et par les enfants. De plus, les parents permettent largement l'utilisation des DA par leurs enfants et modérent certaines utilisations des DA plus que d'autres. Enfin, les enfants entretiennent des relations distinctes avec les assistants numériques et leur attribuent des qualités humaines dans certains cas. Ces résultats contribuent à un corpus croissant de connaissances sur les impacts des technologies avancées d'intelligence artificielle, et favorisent une prise de décision éclairée concernant l'utilisation de cette technologie à la maison.

Mots clés: Intelligence artificielle dans l'enseignement, assistants numériques, théorie des esprits artificiels

Acknowledgements

My sincere gratitude to my supervisor Dr. Adam K. Dube for providing me with the opportunity to work on this fascinating research topic and whose guidance has been integral to the writing of this thesis. I would like to thank project collaborators Dr. Victoria Talwar and Dr. Elizabeth Patitsas for their invaluable contributions to this inter-disciplinary research. I would also like to thank fellow members of the TLC lab who have been a source of support throughout my master's degree. Lastly, I would like to thank participants in the two studies for their valuable time and perspective. Funding for this research was provided by Social Science and Humanities Research Council.

Contribution of Authors

Nandini Asavari Bharadwaj has created study materials, executed the two studies, collected data, and was the sole writer of this thesis. Dr. Adam K. Dube has led project ideation, funding, and design and has overseen data collection, study execution, and thesis writing review. Dr. Victoria Talwar and Dr. Elizabeth Patitsas have collaborated on project ideation, funding, and design as well as provided perspectives on project content as subject matter experts.

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List of Abbreviations

AI	Artificial Intelligence
ANOVA	Analysis of Variance
DA	Digital Assistant
EFA	Exploratory Factor Analysis
HCI	Human-Computer Interaction
ICT	Internet and Communications Technology
NLP	Natural Language Processing
ToM	Theory of Mind
ToAM	Theory of Artificial Minds

"OK GOOGLE, how tall is the sky?" How Children use and understand Digital Assistants

Wealthy developed countries such as Canada, the United States, and the United Kingdom are digitized with high adoption rates of internet and communication technologies (ICT). Digital technologies are referred to as a general-purpose technology, like the steam engine or printing press, for their ability to continuously transform and positively affect productivity across different sectors and industries (Mühleisen, 2018). The "workhorses" of the digital revolution include computers, the internet, and artificial intelligence, bolstered by electrical power and big data, which are extensively available around the globe (Mühleisen, 2018, p.7). According to The World Bank database for ICT use, internet use as a percentage of the population in 2020 was 97% for Canada, 95% for the UK, and 91% for the United States (The World Bank, n.d). Pew Research Center reports that more than 5 billion people have mobile devices to access the internet and that individuals in advanced economies are more likely to have smartphones than people in emerging economies (Silver, 2019). Lastly, A McKinsey report states that the number of connected devices, or household devices like clocks, speakers, or refrigerators that can connect to the internet, is projected to increase from 14 billion in 2018 to 43 billion in 2023 (Dahlqvist et al., 2019). Smart speakers are a prime example of a digitally connected device becoming increasingly ubiquitous in today's home. Canalys (2020) estimates that the global smart speaker install base will reach 640 million in 2024, doubling from 2020.

These impressive adoption numbers do more than just realize a techno-futuristic vision from science-fiction; they fundamentally alter domestic family life. Specifically, it means that today's children, more than any generation in human history before them, are growing up around highly sophisticated technologies. Emerging technologies, such as digital assistants (DAs), are unique in their responsiveness, personification, and interactivity, setting them apart from earlier technologies such as radio or television (Danovitch & Severson, 2021). In a recent study on American families, Pew Research Center reported that 60% of parents said their children (under 12 years of age) use a smartphone, and more than one-third of parents said their child started using a smartphone before the age of 5 (Auxier et al., 2020). Further, a third of parents said their child (under 12 years) interacts with a voice assistant, like Amazon Alexa, and 78% of parents (of children ages 5-11) said their child uses a voice assistant to get information (Auxier et al., 2020). Given this exposure to complex digital technologies from an early age, it is vital to fully understand them and examine issues around use and interaction.

This thesis has been organised as follows. To begin with, background topics such as Artificial Intelligence, Human-Computer Interaction, Digital Assistant technology, and their related issues are discussed. Thereafter, multiple theoretical frameworks that guide the understanding of children’s use and conceptions of digital assistants are considered. Subsequently, two studies conducted to examine how children use and understand digital assistants are presented. Lastly, the thesis concludes with key research findings, limitations, and future directions of the research project.

Artificial Intelligence (AI)

Artificial intelligence powers several key technological devices in today's connected home, such as digital assistants. Artificial Intelligence, as initially proposed, strived to simulate human intelligence in machines by providing machines with precise descriptions and features of human learning or intelligence (McCarthy et al., 1955). Certain vital assumptions are made about intelligence in the quest to achieve artificial intelligence. These assumptions include that intelligence can only be realized in a system capable of incremental and autonomous learning and that learning arises from interactions with different entities in the environment (Pennachin &

Goertzel, 2007). The history of AI research has benefited from a diverse range of philosophical approaches to how intelligence is realized in artificial systems (A. Clark, 1997). These evolved from a) conceiving AI as symbolic systems that engage in computation and symbol manipulation to b) AI as biologically inspired artificial neural network systems that rely on multiple networks of artificial neurons to process information rapidly and to c) AI focusing on embodiment and real-world interactions in robotics whereby intelligence is situated in dynamic interactions with the real world (A. Clark, 1997). Additionally, artificial intelligence is typically discussed in two ways, artificial narrow intelligence and artificial general intelligence (Pennachin & Goertzel, 2007). As indicated by the name, artificial narrow intelligence refers to specialized systems that can perform specific tasks in remarkably efficient ways, such as diagnostic systems or digital assistants (Pennachin & Goertzel, 2007). Artificial general intelligence strives toward human intelligence as a gold standard and aims to be domain-general, efficient, consistent, context-aware, and solve novel problems (Pennachin & Goertzel, 2007; Manning, 2020).

AI Research

AI research is a highly dynamic field of study and has branched into numerous sub-fields that tackle specialized functions like computer vision, natural language processing, and robotics. Developments in this field directly impact the features and functionalities of current and future generations of Digital Assistants (DA). In terms of methodology, AI research often uses cutting-edge mathematical and statistical modeling and prediction techniques with large training datasets to support machine learning in supervised and unsupervised settings (Manning, 2020). AI research has evolved from creating "expert systems" that carefully follow close-ended algorithms to solve problems to focusing on machine learning and more organic interactions with various environments (Manning, 2020, p.1).

Current State of AI developments

With rapid improvements in computer technology and computational power (i.e., Moore's law, Moore (1965)), AI-powered technology is increasingly prevalent globally. It is being used across a broad spectrum of use cases, from self-driving cars to face and voice recognition to workplace efficiency. A 2021 Stanford AI Index report tracks the changes in the field across research, technical performance, the AI education industry, and ethical challenges. From a research perspective, AI-related journal publications have grown steadily over the last decade, 34.5% over 2019-2020, representing 3.8% of all peer-reviewed scientific publications, with global representation seen in research output from academic institutions, governments, and corporations (D. Zhang et al., 2021). From a technical standpoint, AI systems are showing superior performance with generative text, video, and audio, and substantial performance strides are being made in natural language processing and computer vision (D. Zhang et al., 2021). AI investments continue across all industries, with significant investment in biomedical and pharmaceutical industries for drug design and discovery (D. Zhang et al., 2021). Lastly, there has been an increase in the adoption of national AI strategies (e.g., Canada) and research on ethical challenges relating to AI use, like facial recognition (D. Zhang et al., 2021). Taken together, AI and AI-related technology is rapidly growing as a field whose influence is not limited to any one sphere of human life. Across domestic and professional contexts, AI systems impact human life either directly through interactions (e.g., domestic AI technology like digital assistants) or passively (e.g., Decision-making algorithms).

Human-Computer Interaction

The design, implications, and interface of how human and computer or artificial entities interact are studied in the discipline of human-computer interaction (HCI) (Card et al., 1983). In considering the role of psychology in how humans interact with computers, Card et al. (1983) argue that psychological aspects are crucial considerations of user design and application. Unlike previous machines, humans communicate with computers instead of operating them to accomplish tasks (Card et al., 1983). HCI research and AI research are logically linked, and shared topics of interest include speech recognition, natural language, and human-robot interaction (Grudin, 2008). Grudin (2008) argues that the ubiquity of digital technologies in contemporary life may make the field of HCI turn invisible through omnipresence. Today, younger generations grow up having "absorbed the aesthetic of technology design” and do not intentionally interact with devices the way previous generations did, who did not grow up around computers (Grudin, 2008, p. 34). Hence, research into children’s interactions with AI technologies like digital assistants requires a deliberate examination to fully understand the implications of this seemingly invisible ease of use.

Issues in AI and HCI Research

With any rapid technological adoption, it is essential to continually examine the implications of using the technology, especially in sensitive deployment areas such as domestic settings or law enforcement. In the end, AI research is conducted by human researchers and engineers and is used in human environments (e.g., home, work, etc.); hence, there is a significant social element to its design and implementation. Human decisions and value judgments made by engineers are deeply embedded in technology, and these decisions can have far-reaching social consequences and even perpetuate harmful ideas in society (Benjamin, 2019; McEwen & Dubé, 2017; Adams & Ni Loideain, 2019; Wajcman, 1991; Friedman & Hendry, 2019). Human-computer interaction principles emphasizing equity, accountability, and privacy are both challenges and goals for AI and HCI researchers to aspire towards (Friedman & Hendry, 2019). It forms the basis of value-sensitive design that prioritizes ethical and moral considerations for human-technology interactions (Friedman & Hendry, 2019).

Shneiderman et al. (2016) highlight 16 grand challenges for HCI researchers, designers, and developers, including–a deep understanding of human needs, promotion of lifelong learning, securing cyberspaces, and clarifying responsibility and accountability for interfaces and tools like algorithms. Thus, as the field evolves, it will be essential to continually consider the benefits of using this technology versus the risks. Indeed, as technology is ever-present in today's home, notions of technology users and stakeholders may broaden in the familial context. Friedman and Hendry (2019) describe direct stakeholders as those who interact with the technology in contrast to indirect stakeholders who are affected by technology. Children growing up around intelligent technologies may find themselves in both these categories. Further, due to their age and vulnerable social position, children represent a "special population" that should be studied to fully understand the implications of any novel technological system (Friedman & Hendry, 2019, p. 42).

Digital Assistants (DA)

Digital assistants, also known as voice assistants, digital voice assistants, or virtual assistants, are AI applications that rely on voice queries to support a variety of tasks for users (Hoy, 2018; Maedche et al., 2019). Modern DAs have been commercially available since 2010 through different providers such as Apple, Microsoft, Amazon, and Google (Hoy, 2018). These technology companies have proprietary virtual assistants with distinctive names and "personalities," such as Apple Siri, Amazon Alexa, Google Assistant, or Microsoft Cortana. Current DAs use AI technologies such as natural language processing (NLP), speech recognition, machine learning, and knowledge representation to support tasks and possess higher levels of interactivity and competency than previous DA generations (Maedche et al., 2019). Notably, DAs are disembodied virtual agents and can be deployed across different hardware platforms like speakers, smartphones, clocks, or screens (Hoy, 2018).

Size and Scale of Smart Speaker Market

Smart speakers are massively popular worldwide and have unassuming physical designs that can be discreetly placed around the home. The installed base of smart speakers is estimated at an incredible 320 million units and is projected to grow exponentially (Canalys, 2020). In 2021, the global smart speaker market was projected at 19.6 billion dollars (Loup ventures, 2019a), and it is estimated that 180.5 million smart speakers will be sold worldwide (Loup ventures, 2019b). Around the world, some smart speaker brands are more popular than others—in Canada, Google Home (Google Assistant) is the most popular; in the USA, India, Brazil, and the UK, Amazon Echo (Alexa) is the most popular, and in China, Redmi (Xiaomi) is most popular (Statista, 2021). These staggering numbers translate to DAs being commonplace in homes and across various devices in the developed world. Nearly half of American adults in the USA typically use digital assistants on their phones (Pew Research Center, 2017) and one-fourth of Americans now own a smart speaker at home (Auxier, 2019). Low prices, ease of use, and convenient features have contributed to the dominance of DAs, particularly smart speakers, in the home.

Technical Features and Functionalities

DAs are AI entities that users can interact with primarily through voice. DAs are sensitive to their respective proprietary "wake words" which allow them to receive, record, and subsequently process requests in cloud-based servers (Hoy, 2018; Maedche et al., 2019). For example, per factory settings, Amazon products will listen for "Alexa," Google products for "OK Google," and Apple products for "Hey Siri." Once a device recognizes a wake word, natural language processing, and speech recognition allow it to understand the subsequent request and process it for the user; once the task is completed, DAs can communicate back to the user through text-speech synthesis (Hoy, 2018; Maedche et al., 2019). What is more, commercial DAs rely on advanced machine learning so that the highest ranked results from the internet can be returned to users (Google, n.d.) and so that DAs can learn from a diverse range of users and user requests for future interactions (Amazon, n.d.). These technical features facilitate a unified interactive experience with users that often mimic human conversation conventions.

DAs boast a wide range of functionalities to assist users at home and elsewhere. In this way, DAs represent a "socio-technical system" that relies on the interplay between 3 elements—the user, the task, and the technology (Maedche et al., 2019, p. 535). Broadly, commercial DAs support a wide range of tasks from information search on the internet to media play to clock functionalities (timers, alarms, etc.) to smart home control (Hoy, 2018; Maedche et al., 2019). Popular functionalities include playing music, information search, and smart-home control (Ammari et al., 2019). These in-built capabilities allow for narrowly defined task completion and were the focus of the first generations of DAs (Ram et al., 2018). Beyond the in-built and classic capabilities of DAs, commercial DAs can interface with other programs or complete more complex actions, known as Alexa "Skills" or Google Assistant "Actions" (Hoy, 2018, p. 83). These additional features may be built by third-party developers or by users themselves and installed on DAs like apps (Hoy, 2018). Additionally, users may also combine DA features and smart home functions to create complex "routines," such as a morning routine that may turn down a thermostat, switch on a coffee machine, and play the daily news on a speaker through a single command (Hoy, 2018, p. 83).

DAs and Children

Commercial DAs are often positioned in their advertising as a smart-home essential and helpful addition to family life. In doing so, commercial DAs also target children as their end-user with devices and features. Amazon has a "Kids" edition of its massively popular echo dot speaker with child-focused features and animal-inspired physical designs (Amazon, n.d.). Google Assistant offers story time modes that can read bedtime stories aloud to children or read alongside a child as well as educational activities for the whole family (Google, n.d.). Country-wise differences also exist in terms of offerings. Amazon UK has bundled several parental controls and features, including content filters, time limits, and activity reviews (Amazon UK, n.d.). Additionally, several child-conversation-focused features, such as a "Magic Word" feature, provide positive reinforcement when children are polite to the DA, educational Q&As, and the ability to offer content when a child mentions they are bored (Amazon UK, n.d.). What remains under-researched or publicly inaccessible is how children use these functions or conceive of these devices.

DAs as Learning Devices

Commercial DAs have the potential to be impactful learning devices in the home in two ways. First, directly as an information source, DAs provide access to a wealth of knowledge by utilizing ranked internet searches for their voice queries (Hoy, 2018). Lovato et al. (2019) have argued that children may view DAs as information sources as they access DAs for questions, especially before they can read. In their study, Lovato et al. (2019) found that children asked DAs about topics they were curious about, such as science and technology, and proposed that DAs could play a role in self-directed learning. Second, through social interactions. Bailey et al. (2021) have proposed that conversational agents like DAs can support learning by acting as expert peers. Conversing with DAs, that are human-like in their responses and social graces could help children learn from the device as well as view DAs as peers to affect learning outcomes and increase motivation (Bailey et al., 2021)

Future of DA Technology and Relevance to Children

The future of DAs includes higher projected market growth (Canalys, 2020), widespread use (Loup Ventures, 2019b), and more sophisticated technology (Perez, 2021). These developments will continue to have repercussions for child development in the home. One area of rapid improvement is the conversational capabilities of DAs and related products. Researchers at Amazon are actively looking to improve the capabilities of "Conversational AI" to allow DAs to have a more natural and engaging dialogue with human conversation partners (Ram et al., 2018, p.1). Through the Alexa Prize, a yearly university-based competition, researchers set out to build conversational agents that interact with users to improve fields of natural language understanding, speech recognition, and context modeling (Ram et al., 2018). Google Duplex is a powerful technology that conducts natural human-like conversations in real-world scenarios such as booking appointments or restaurant reservations (Leviathan & Matias, 2018). Google Duplex integrates with Google Assistant and can help users conduct transactions with an external business or restaurant without any human intervention (Leviathan & Matias, 2018).

Another area of change is how people interact with these devices. Currently, most interactions with DAs are user-initiated; however, commercial DA technology companies envision a future where DAs may take actions more autonomously on behalf of users. Techcrunch reports on Alexa's new features that prioritize preference teaching and learning user behaviors in domestic life to attain "Ambient AI" or ambient intelligence at home (Perez, 2021). Ambient intelligence will allow the connected home to understand the home environment and user and take predictive actions, e.g., calling the police if a window break is heard late at night (Perez, 2021). Further, other media reports indicate that Amazon Alexa will become more embedded in domestic life, and its predictive utility will expand to maintaining extended conversations and providing activity recommendations akin to a human (Cain, 2022). In this way, Alexa products are being increasingly positioned as useful members of the household (Cain, 2022)

While AI-powered devices, their underlying technology (e.g., machine learning, NLP, etc.), and interactions with humans are typically studied in AI research and Human-Computer Interaction research, here an educational psychology approach is adopted. As outlined, due to the rapid and widespread adoption of DA technology and the specific focus on children in product and feature design, it is crucial to fully understand the technology and its psychological and educational impact. While research on children's interactions with Digital Assistants from different disciplines has been growing in the past decade (Druga et al., 2017; Festerling & Siraj, 2020; Garg & Sengupta, 2020; Girouard-Hallam et al., 2021; Lopatovska & Williams, 2018; Lovato et al., 2019; Sciuto et al., 2018), there is more enquiry needed about how DAs and DA use relate to child development and learning. A first issue is how children develop to understand the technological world around them with all its inhabitants, human and artificial. A second issue is how these children learn from the technologies around them, given that children can use voice-enabled technologies to search for different kinds of knowledge and learn about the world.

Theoretical Frameworks to Understand Child-DA Interactions

How children use and understand digital assistants involves the consideration of children's development, their understanding of AI technology, and their relationship to AI entities. These considerations lie at the intersection of multiple fields, and as such, an interdisciplinary approach is needed. Therefore, guiding theories and methods from Psychology, Philosophy, AI, HCI, and Computer science are considered to explore the intersectional nature of the topic.

Theory of Mind

Theory of Mind (ToM) relates to how people understand their own minds and others around them (Wellman, 2018). Due to DA's interactive and sophisticated conversational capabilities, ToM can be extended to artificial entities. Just as ToM is concerned with how individuals understand their own and other minds, it is important to consider how developing children may conceive of an artificial "mind" like that of the DA. Given its subject matter, ToM has a rich history of inquiry within philosophy of mind and developmental psychology. Wellman (2018) observes that, at a basic level, philosophers and psychologists agree that people understand others through three types of mind and behaviors, namely beliefs, desires, and intentional action.

In philosophy of mind, there are diverse approaches to studying mind and body. Substance dualism championed by Descartes holds that mind and body have different spatial and phenomenal properties and that while the mind is known with certainty by thinking beings, the body may not; Panpsychists assert that the mind is a fundamental aspect of reality and that everything has a mind; Identity theory states that the mind and brain are identical and mental properties are physical properties of the brain; Functionalism posits that mental states, defined as causal relations to input, output and other mental states, can be realized in multiple ways (Mandik, 2013). Other critical ideas studied in philosophy of mind are notions of self, thoughts and experience, will and action, the problem of other minds, and thinking machines (Mandik, 2013). These ideas are actively debated, from different aforementioned approaches, as the notion of how humans understand their minds, other minds, and other seemingly intelligent minds (e.g., conversational AI) is neither straightforward nor commonly understood (Mandik, 2013).

The field of psychology is similarly keenly interested in the study of the mind and how it can be studied in humans across their lifetime. The American Psychological Association defines

Theory of Mind as "the understanding that others have intentions, desires, beliefs, perceptions, and emotions different from one's own and that such intentions, desires, and so forth affect people's actions and behaviors" (APA, n.d.). ToM corresponds to a group of cognitive skills that facilitate reasoning about affective states like emotions or other cognitive skills like beliefs (Beaudoin et al., 2020). Developmental psychologists are interested in how ToM emerges in young children and how children begin to understand their mental states and that of others (Beaudoin et al., 2020; Gopnik & Wellman, 1992; Gordon, 1986; Wellman, 2018; Wimmer & Perner, 1983). ToM is observed in children as early as 6-8 months old and develops into a skilled competency in typically developing children by ages 5-6 (Beaudoin et al., 2020; Wellman, 2018). Beaudoin et al. (2020) summarize that ToM comprises numerous skills related to social interaction, such as belief attribution that allows for smooth social interactions. ToM competencies, particularly more complex ones needed to manage second-order false belief tasks, are observed to advance throughout childhood and into adolescence, and even adulthood (Beaudoin et al., 2020).

ToM Studies and Methods

Children's understanding of mental states has been studied by assessing how agents' desires and beliefs come together to produce intentional actions and assessing children's understanding of different ontological categories such as thoughts and physical objects (Wellman, 2018). The development of ToM is typically observed in experimental settings using various child-friendly modalities, such as read-aloud stories or picture-based scenarios, that relate to ToM competencies and abilities (Beaudoin et al., 2020). Beaudoin et al. (2020) review ToM-related measures across 830 ToM studies related to mental states such as emotions, desires, intentions, percepts, etc. Examples of popular ToM tasks include tasks that measure inference of others' emotions based on situational context, understanding that different people may have different desires or understanding that people may act on false beliefs (Beaudoin et al., 2020). With a view of the developmental progression of ToM, Wellman and Liu's (2004) Theory-of-Mind scale highlights the order of difficulty of ToM competencies and development in typically developing children. Children show a consistent development pattern across countries such as the U.S, Canada, Australia, and Germany (Wellman & Liu, 2004). Children first begin to understand that people have different desires (DD) for the same things, then children understand that people may have different beliefs (DB) about the same situation; subsequently, children may learn that something can be true and a person may not have access to that knowledge (KA), followed by understanding that something can be true, but someone may believe something false (FB) and finally that someone can show a certain emotion but feel a different way entirely (HE) or "DD>DB>KA>FB>HE" (Wellman, 2018, p. 735). Interestingly, country differences exist, and children from China, Iran, and Turkey show a different ToM sequence where KA and DB are reversed as "DD>KA>DB>FB>HE", which highlights different parenting styles and cultural norms in more collectivist cultures (Wellman, 2018, p. 738).

ToM and Digital Assistants

ToM is pertinent to how children use and understand digital assistants for two reasons. First, due to their interactivity, DAs represent a social entity in the domestic sphere, albeit an artificial inorganic one. Furthermore, digital assistants closely resemble human social conventions in their conversation mannerisms, and children's observed engagement with voice assistants suggests patterns similar to intra-human interactions (Festerling & Siraj, 2020; Festerling & Siraj, 2021). Similar ToM mechanisms that allow children to understand and interact with others around them (e.g., belief attribution or intention inference) might be at play when a child interacts with conversational AI like the DA. Secondly, how children conceive DAs in terms of beliefs, intentions, or desires may ultimately impact their interactions and trust in technology. Lovato et al. (2019) note that children used human adjectives such as "friendly" and "trustworthy" (p. 302) to describe DAs and expected the device to carry out conversations as a person would. In observing children's interactions with robots, Brink and Wellman (2019) found that their beliefs about technology evolve with age and impact children's interactions with intelligent technologies.

Theory of Artificial Minds

Theory of Artificial Minds (ToAM) is a novel theoretical framework proposed in response to the ever-increasing presence of intelligent machines in human lives (Bharadwaj, Dubé, Talwar & Patitsas, In press). ToAM is an extension of the notion of ToM that relates to AI systems. ToAM is conceived of the ability to infer internal logical states of intelligent technologies during technology use. Like ToM, this ability will be reciprocal in nature.

ToAM posits that humans and AI systems will require a reciprocal ToM to communicate with each other successfully and meaningfully. The reasons are twofold. First, as discussed previously, humans require a ToM and related ToM mechanisms to successfully interact with other humans (Beaudoin et al., 2020). Social interaction involves significant behavior prediction, justification, explanation, and coordination (Andrews, 2015), and ToM mechanisms such as belief, intention, or desire attribution allow for frictionless interactions. Second, AI systems are already entrenched in the social world. As previously discussed, AI systems are being used across diverse use cases and industries (D. Zhang et al., 2021). Of particular interest is how AI systems are used in situations involving human interaction, such as customer-service chatbots, digital assistants, and even autonomous vehicles. Hence, just as a ToM is required to successfully navigate a social world, with the arrival of AI systems in the social realm, it follows that a similar mechanism will be needed to ensure smooth and seamless interactions between humans and AI systems. A fulsome and robust ToAM between humans and AI systems can set the stage for much-needed successful social partnership.

Developing a ToAM about artificial entities has key benefits for humans. First, it provides predictive utility. ToAM, like ToM, assumes that AI systems like humans have certain beliefs, desires, and intentions that affect their behaviours and actions. While not similar in structure or function to human ToM mechanisms, it is still helpful to conceive AI systems as having certain internal states that drive their behavior. Given that both brains and AI systems possess a similar "black-box" problem of inaccessibility (Castelvecchi, 2016, p. 21), it is a helpful metaphor to keep in mind. Assuming AI systems possess specific intentions about a particular task may help predict how an AI system will respond in a given situation. For example, assuming that a DA intends to provide answers to objective questions by accessing information on the internet. This will ensure that users ask questions that DAs can actually answer and anticipate that their requests will be processed appropriately. Second, it could help humans understand technological systems better. Danovitch (2019) summarizes findings demonstrating that children have a limited understanding of how digital technologies, like the internet, work or what they can do, despite exposure. Studies have shown that both children and adults sometimes do not demonstrate a complete understanding of the internet, despite its ubiquitous use (Yan, 2009). Further, researchers have found that even programming novices often struggle to understand how the interface they interact with (the notational or mental machine) interacts with the actual physical hardware (the computer) and may not have appropriate mental models for how systems function (Evangelidis et al., 2001; Khalife, 2006). ToAM can bring together computational thinking, theory of mind, and computer science concepts to help people better understand how complex artificial systems work. Of specific interest is how ToAM could help children better understand devices such as digital assistants. Whether children developing a ToM (ages 3-6 years) about other people are similarly developing any conceptual frameworks about intelligent interactive technologies is unknown.

ToAM is a new and evolving theoretical framework, and its methods and techniques to measure children's evolving ToAM are to be established. Recent research has uncovered fascinating ways that children understand AI and robot systems. Y. Zhang et al. (2019) found that typically developing children readily attributed false beliefs to robots during ToM tasks and termed it a "theory of robot mind" (p. 1). When children were asked to observe and explain an adaptive robot's behavior, Levy and Mioduser (2008) reported that children used a mix of technological and psychological explanations to explain the robot's actions, depending on task difficulty. Spektor-Precel and Mioduser (2015) found that as children observe "behaving artifacts" (p. 329), they become more reflective of AI and human mental capabilities. In their study, Spektor-Precel and Mioduser (2015) define ToAM as a mental understanding that AI systems like robots have “no will" (p. 335), and their operation depends on programming or operation in response to environmental conditions. Children's interactions with behaving artifacts, particularly at ToM-sensitive ages (5-7 yrs), influenced the development of ToAM and other metacognitive abilities (Spektor-Precel & Mioduser, 2015)

Affordance Theories

Gibson (1977) defined affordances as behaviors that are possible when an agent interacts with a given object in an environment. Hence cups or bowls afford liquid drinking, as perceived by a human or animal capable of drinking liquids. Grounded in the ecological approach, an affordance of an object lies in the interaction between agent and object (Gibson, 1977). Notably, Gibson's (1977) affordance approach posits affordances as fundamental objects of perception, and people can directly perceive affordances without significant cognitive interventions such as memory (Gaver, 1991). As Dubé and McEwen (2017) have argued regarding tablets, Gibson (1977) affordance theory creates unique issues for digital objects, as possible behaviors are far more constrained than analog-designed objects. Similarly, DAs perform in a way dictated precisely by developers, and possible behaviors are not as readily open-ended to lay adults, let alone young children. Additionally, affordances may be perceived in different modalities beyond visually, such as through sound or touch (Gaver, 1991). Gaver (1991) explains that sounds can convey information about affordances regarding size or material, especially when an affordance cannot be seen. Sounds, of particular importance to discreetly designed voice-based DAs, convey far more about the affordances of the device than its physical design.

Norman (1999) elegantly extends Gibson (1977) notion of affordances to distinguish between real affordances and perceived affordances. Norman (2002) similarly specifies that affordances are fundamental properties of objects that provide "clues to the operation of things" (p. 39). Real affordances constrain a set of possible actions for an object, specifying what an object can do, whereas perceived affordances relate to what a user thinks an object can do (Norman, 1999). Norman (1999) highlights the importance of this demarcation, particularly for graphical screen-based interfaces where designers can only control perceived affordances, as device hardware already have physical affordances.

Affordance Theories and Digital Assistants

DAs are a salient example to highlight the distinction between real and perceived affordances. If we consider that virtual DAs can be embodied across different hardware platforms like a phone, smart speaker, or clock, then the real affordances of each device will obviously differ significantly. Each device has different physical designs, shapes, buttons, and screen functionalities. A speaker may afford sound playback and recording; however, the DA within it affords hundreds-more behaviors based on how it has been programmed. Perceived affordances and education of users are also challenging in DAs, given that DAs rely on voice commands and not signposts, visual labels, or text-based information to the user. Further, removing the internal DA will not affect the affordance of the physical speaker. Conversely, only knowledge of the affordances of the technological device, or a conceptual model of some kind, will guide the user to interact with it, as the device itself does not provide it (Dubé & McEwen, 2017). Norman (2002) asserts that good conceptual models allow users to effortlessly understand how an object could work, its constraints and predict the effect of their actions. Hence of critical interest to designers is how users perceive what the digital tools can do, as it impacts how they view the product in their lives (Norman, 1999).

For children, real and perceived affordances of DAs will play a significant role in how children conceive of and use DAs. While real affordances of DAs may be similar for both adult and child users, commercial DAs may face issues in their speech-recognition affordance as it relates to children. Voice assistants sometimes struggle to understand what a child is saying, thereby causing breakdowns in communication and task completion (Cheng et al., 2018; Sciuto et al., 2018). Hence, this may impact how children perceive the real affordance of the DA. On the other hand, perceived affordances may differ more drastically for adults and children. Children's perceived affordance will be influenced by developmental progression and prior experiences (Dubé & McEwen, 2017). For children, physical and cognitive development will allow them to interact and discover affordances of the device (Dubé & McEwen, 2017). For voice-based DAs, this may particularly pose problems for young children as they are still learning to speak clearly and gain vocabulary (Cheng et al., 2018; Druga et al., 2017). Further, studies have shown that younger children (under six years) are more likely to believe that a voice interface is a human behind-the-scenes instead of a technical interface (Cheng et al., 2018; Druga et al., 2017; Festerling & Siraj, 2020). Intuitively, more exposure to technology can help children improve their understanding of technology. Prior experiences can include both experiences with the device as well as observations made of others, like parents, using the device (Dubé & McEwen, 2017). Indeed, children can learn the affordances of a technology and understand its limits, constraints, and functionalities as they gain more exposure and familiarity with a technology (Holzinger et al., 2011). Given the considerable adoption numbers of DAs worldwide, familiarity with a voice-based digital assistant and the role of parents will only continue to grow in the following decades.

Parental Mediation Theory

Parental mediation theory regarding media first originated regarding television use in the home (L. Clark, 2011; Dorr et al., 1989; Jiow et al., 2017). When television rose to prominence in American households in the 1960s, parents took an active role in mediating the use of this new media to contextualize what was presented on the screen to young viewers (L. Clark, 2011; Troseth & DeLoache, 1998). Young children perceived television in unique ways, assuming that what they saw on screen was real and taking place physically inside the TV set (Nikken & Peeters, 1988). Beyond children's understanding of the technical working of the TV, parents were also concerned with the messaging in TV content, exposure to commercial products, and viewing time (L. Clark, 2011).

L. Clark (2011) summarizes parental mediation theory as a hybrid communication theory that examines psychological and social media effects and emphasizes the importance of communication between parents and children. Parental mediation theories assume that parents utilize different strategies to mitigate adverse media effects for their children and that these strategies may play a role in how children get socialized in society (L. Clark, 2011). Standard scales developed to measure mediation strategies describe three strategies used by parents–Active mediation, which describes parents discussing TV content with their children; restrictive mediation, which involves rule-setting and regulations around TV use; and Co-viewing, which involves parents watching TV with their children (Valkenburg et al., 1999 and Nathanson, 1999 as cited in L. Clark, 2011). Characteristics of parents and children may affect the frequency and duration of mediation strategies. Gender, education, income, and ages of children may affect mediation strategy usage with fathers, less-educated, lower-income, and parents of older children reported to employ less mediation strategies than others (L. Clark, 2011). Further, as children grow older, the perceived need for parental mediation often decreases (L. Clark, 2011).

Parental Mediation in the Information Age

The family media landscape has shifted significantly from the television era. The digital media landscape in homes across the world today is increasingly complex, interactive, immersive, and social (L. Clark, 2011; Jiow et al., 2017; Livingstone & Helsper, 2008). The internet provides access to exceptional amounts of information across multiple modalities; however, it also creates novel problems regarding child safety, trust, and misinformation (L. Clark, 2011).

Researchers are actively studying how parental mediation might look across contemporary media modalities such as the internet and gaming. Livingstone et al. (2017) highlight that with widespread internet use, newer strategies for mediating internet use are emerging for parents that challenge the neat active/restrictive/co-viewing framework used in TV mediation. Parents not only use restrictive mediation strategies such as time limits and bans on specific content but can also avail of technical controls that filter out content (Livingstone & Helsper, 2008). Livingstone et al. (2017) propose six parental mediation strategies for internet use–active mediation of internet use, child-initiated support, active mediation of internet safety, technical controls, parental monitoring, and parental restrictions. Notably, Livingstone et al. (2017) resolve these six strategies into two broad independent categories: enabling and restrictive. Enabling mediation strategies encourage children's internet use and promote children's agency in interactions with their parents, whereas restrictive strategies discourage internet use and child agency (Livingstone et al., 2017)

Jiow et al. (2017) highlight that the video game industry is rapidly evolving with new content genres, types of gameplay, and player interactions, and these changes mean that parental mediation theory must evolve alongside. For example, parents may need to make more effort to research and understand a game genre, content and gameplay before restricting the use of a particular game, as opposed to simply relying on government classification of age-appropriate media content (Jiow et al., 2017). Jiow et al. (2017) propose that parental mediation for contemporary media like gaming consists of gatekeeping, investigative activities, discursive activities, and diversionary activities instead of the prevalent restrictive, active, and co-use frameworks. Jiow et al. (2017) argue that activities where parents can spend more time understanding new media or, in some cases introducing alternative media more accurately capture the range of mediation activities that parents today must engage with.

Parental Mediation Theory and Digital Assistants.

Like the internet and other media devices, parental mediation of DAs should strive to “maximize benefits and minimize risks” for young children (Livingstone et al., 2017, p.82). Beneteau et al. (2020) highlight that while parents actively mediate DA use at home through verbal regulation and gatekeeping use, DAs can also provide a unique opportunity to augment parenting. However, given DA's access to information on the internet and conversation abilities, parents must understand the impacts of DA use on their children and mediate responsible use. At a user level, DAs pose risks in how information is provided to users, how domestic privacy is maintained, and how data is controlled and shared (Stucke & Ezrachi, 2017). DAs can likely conduct independent interactions with young children due to their placement around homes. Beyond information and privacy risks that affect the legality of DA use (Stucke & Ezrachi, 2017), there may also be risks that could physically harm young children. The Verge reports a recent incident where an Amazon Alexa instructed a young child to complete a "challenge" involving a live electrical circuit (M. Clark, 2021). Hence, parents today need to be aware of how DA technology functions and how DA interactions might impact their growing children.

Findings from Research on Children and Digital Assistants

Researchers from a diverse range of disciplines, from experimental psychology to HCI and robotics, use various methods and measures to study how children across different age groups interact and understand digital and embodied AI technology around them. Several empirical studies discussed subsequently have examined children's open interactions with voice-based DAs and observed how children ask DAs queries and how they conceive of DAs as entities. Overall, this research has generated novel insights about child-AI technology interactions but also establishes the need for research to explore additional facets of intelligent technology use and individual differences of young users. What follows is a brief literature review of research focused on children's interactions with intelligent machines like DAs and how children understand these technologies.

Children's Understanding of New Technologies

Danovitch and Severson (2021) argue that the proliferation of digital technologies and the focused study of how children understand these novel technologies present a unique opportunity to understand how human cognition adapts to new environments and experiences. Danovitch and Severson (2021) present three emerging themes in the study of children's understanding of technology. First, cognitive gains are required for children to fully understand the affordances of technology around them beyond mere exposure and familiarity. Second, despite high levels of exposure to screen-based media, contextual factors such as collaboration with adults and parental influence play a pivotal role, and third, children gradually learn to effectively use technology to achieve their goals, despite early challenges (Danovitch & Severson, 2021)

Children's conceptions of Digital Assistants

In considering how children think of DAs, the evidence shows a complex understanding of DA capabilities, often mediated by the child's age. Festerling and Siraj (2020) observe that children in their study thoroughly enjoy interacting with DAs and actively probe DA identities through personal questions to the DA. Children attributed both humanoid and non-humanoid capabilities to DAs and could consider DAs as the middle ground between living and non-living entities (Festerling & Siraj, 2020). Xu and Warschauer (2020) multi-modal study uncovered that children attribute both artifact and animate properties to DAs or neither, and most participants ascribed cognitive and behavioral properties to DAs. In their study, Xu and Warschauer (2020) encountered nuanced reasoning of DA behavior from children, suggesting that DAs could be considered both living and non-living or perhaps a third category. Girouard-Hallam et al. (2021) found that a majority of children in their study attributed some mental (e.g., thinking), social (e.g., companionship), or moral (e.g., trust) attributes to a familiar DA. Further, younger children were more likely to attribute moral and social qualities than older children, suggesting developmental factors at work (Girouard-Hallam et al., 2021).

Children's interactions with Digital Assistants.

As children interact with DAs in the home, researchers are interested in popular search queries, search categories, and how queries are phrased to the DA. Lovato and Piper (2015) categorized children's open-ended interactions with DAs primarily into three categories: exploratory or relational questions, information-seeking questions, and functional questions. In subsequent studies, Lovato et al. (2019) reported that children most often searched for science-related topics (animals, plants, and nature), followed by pop culture and practical questions (weather etc.) and questions about the agent itself. Given that children preferred to ask "why" and "how" questions, DAs were only able to answer children's questions fully about 50% of the time (Lovato et al., 2019). Oranç and Ruggeri (2021) similarly found that children prefer to ask information-seeking questions first, followed by agent-related questions in their laboratory-based study. Upon receiving an uninformative response, older children were more comfortable adapting their questions than younger children–suggesting that as children grow up around DAs, they may become more comfortable DA users (Oranç & Ruggeri, 2021)

Children's relationships with Digital Assistants

Multiple studies have shown that children readily ascribe personality characteristics to DAs and personify the devices. In their study observing open interactions between children and DAs, virtual agents, and chatbots, Druga et al. (2017) found that children perceived intelligence and friendliness in artificial agents and tried to understand them as people. In a two-year study, Garg and Sengupta (2020) observe that personifications of DAs by children (ages 5-7 years) not only endured but that children develop emotional attachments to the devices. Hoffman et al. (2021) report that children develop para-social relationships and have para-social interactions with DAs, often becoming close to DAs and developing attachments. However, while children enjoy interactions with voice assistants, Aeschlimann et al. (2020) found that children shared less information with them during collaboration tasks. Aeschlimann et al. (2020) propose that children may have different expectations from AI systems than human partners, which may drive different principles of cooperation.

Family Dynamics and Digital Assistants

As children interact with communal DAs, it is observed to affect other relationships and family dynamics. Purington et al. (2017) observed that children were more likely to personify DAs and that DAs were more likely to be personified when situated in familial settings. Through a voice-log and at-home study, Sciuto et al. (2018) observed that children's interactions with the DA affected their relationship with other technology and their conversational style with other household members. Communication breakdowns were observed to happen often with DAs, and families play a pivotal and collaborative role in repairing breakdowns, especially with young children (Beneteau et al., 2019). Beneteau et al. (2020) found that DAs can play a supportive role in parental practices such as regulating children's free time or engaging in daily routines like bedtime. Garg and Sengupta (2020) suggest that DAs can be embedded within family practices such as mealtimes to enhance communication within families and be designed to promote positive conversation etiquette. Biele et al. (2019) similarly describe the positive influence that DAs can have on children's linguistic habits (e.g., encourage politeness), social relationships, and the home environment.

Research over the last decade has tried to keep pace with the speedy adoption of DAs worldwide. Festerling and Siraj (2021) emphasize that DAs are distinctive as technological devices not just because of their widespread adoption but also because of how rapidly their designs and technological capabilities have come to mimic natural human speech. Research on children's use of DAs so far has produced interesting insights; however, it is still in early days. Comprehensive insights into DA use, patterns of information search, and child-DA relationships are not easily accessible to the research community and broader society due to commercial ownership of user data. Further research is needed on how DAs are used in the home, how parents mediate DA use and how children relate to these devices. Further, no current research has explored the concept of ToAM as it relates to DA use. Therefore, it is vital to contribute to a growing body of research regarding how children use, understand, and relate to DAs around them. Theoretical frameworks discussed, such as ToM, ToAM, affordance theories, and parental mediation theories, guide the design and execution of the current research project.

Determining How Children Use and Understand DAs

As previously discussed, it is crucial to understand the use of DAs in the home and their impacts on growing children. From a learning sciences perspective, it is vital to understand DA use and implications for three reasons. First, DAs represent a knowledge device. Previous research has indicated that DAs are primarily used for information search (Garg & Sengupta, 2020; Lovato et al., 2019; Oranç & Ruggeri, 2021). Given this, DAs facilitate learning in real-world and informal contexts. Second, DAs are interactive, mimic human social conventions, and are primarily voice-based (Bailey et al., 2021; Beneteau et al., 2020; Festerling & Siraj, 2020; Hoy, 2018). In this way, DAs may have powerful impacts on social cognition and the development of mechanisms that aid social interactions, such as Theory of mind. Lastly, DAs are sophisticated technological devices that possess artificial intelligence and access the internet for search queries (Hoy, 2018). Thus, DAs can contribute to technology-rich learning environments at home and have the potential to be used in formal educational settings in years to come.

Research Project Objectives and Related Theory

Overall, the current project builds on previous work on child-DA interactions (see Druga et al., 2017; Festerling & Siraj, 2020; Lovato et al., 2019) by exploring patterns of use, interaction, and relationships. As previously mentioned, more research is needed to understand the psychological and educational impacts of DA use. In theorizing this novel area of inquiry, ToM frameworks establish whether children readily attribute mental attributes to DAs, affordance theories help establish real and perceived affordances of DAs, and parental mediation theory facilitates an understanding of the role parents play in regulating DA use at home. A key objective of this project is to explore and establish a novel theory of artificial minds (ToAM) to aid in understanding how children use and learn from DAs.

Research Project Components

This multi-year project is divided into three components: a pilot study, a more extensive online study, and an in-person study. Each project component is incremental, building on insights from the previous component and addressing parts of the overall research objective. Due to the limited number of previous studies on how parents and children use DAs at home, there was no strong basis on which to ask about DA use. Hence, an open-ended survey was conducted in the pilot study (Phase 1) to establish how DAs are used at home, popular information-search queries, and whether there are unique ways that children relate to DAs. The second, more extensive online study uses insights gained from the first study in establishing distinct categories for DA use, knowledge search, and child-DA relationships and also includes a novel measure for DA parental mediation (adapted from Livingstone et al., 2017). The third in-person study is a proposed empirical study with children to observe their live interactions with DAs, their understanding of AI-based DAs, and ToAM-capacities. In this thesis, the first two project components will be presented and discussed, and the third component is planned to take place in subsequent years.

Study 1: DA Use and Interaction Measure Development

This study takes a dual approach to understanding how DAs are used in the home with the goal to develop measures to assess common uses, search queries, and child-interactions. The two approaches include collecting information directly from parents through a small global sample as well as reviewing relevant studies in the literature and industry standards of DA use categorizations. The study explores three facets of DAs in the home. First, how DAs are used by families in daily life, second, common topics of information or knowledge search, and third, how children relate to these interactive voice-based devices. Consequently, the guiding research questions are:

RQ1: What are the range of DA uses for families (parents and children) in the home?

RQ2: What are the range of common knowledge-based topics that families (parents and children) search on their DAs?

RQ3: What are the range of ways that children interact with DAs?

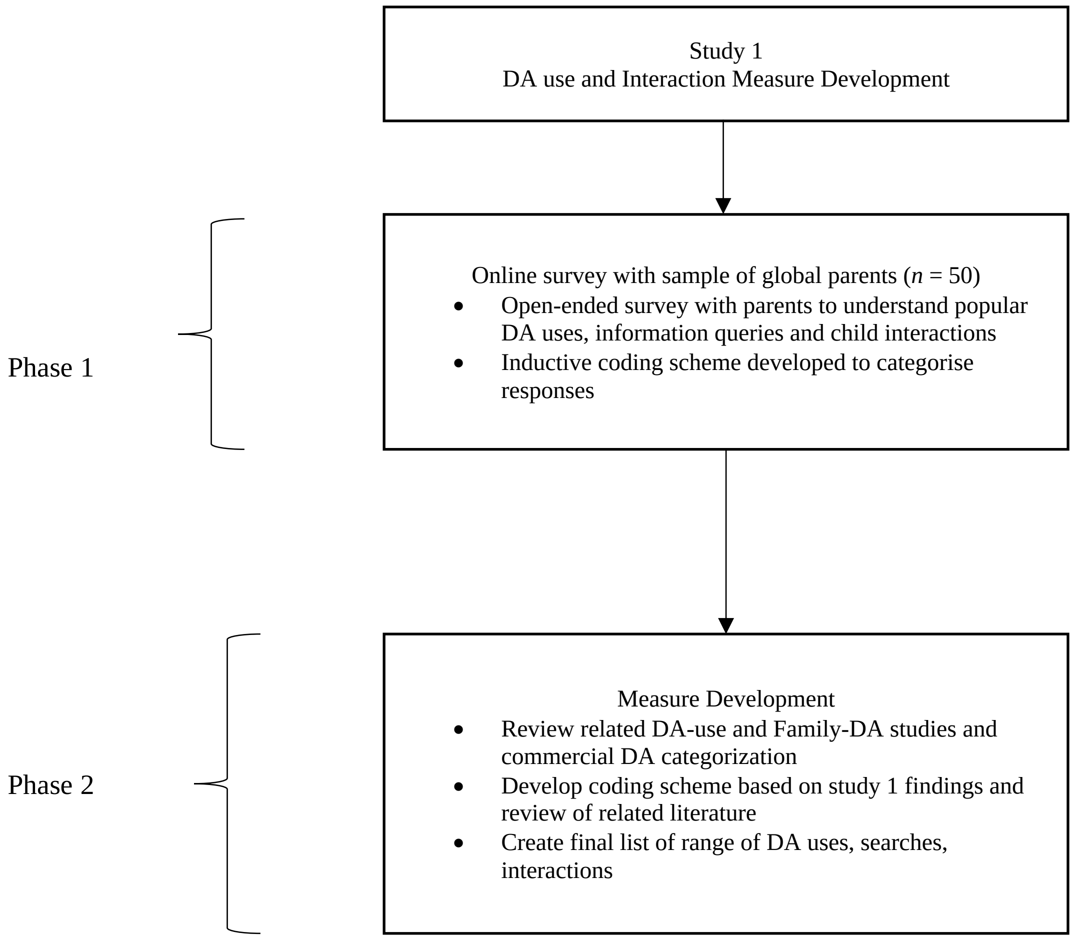
RQ4: What are the range of descriptions of child-DA relationships?

Method

The study was conducted in two phases (see Figure 1). Phase 1 involved an online survey of a small sample of global parents to understand popular DA uses, knowledge search queries and child-DA interactions. Phase 2 involved measure development based on insights gained from Phase 1 as well as through consulting related studies and categorization by commercial DA companies.

Figure 1

Study 1 Research Process Flowchart



Participants (Phase 1 Survey)

Participants consisted of 50 English speaking parents of children (ages 4-8 years) who have a smart speaker/DA in their homes. Prior to data collection, ethics approval for the study was obtained from McGill Research Ethics Board. Participants were randomly selected out of a pool of ~2000 eligible participants on Prolific[1]. Data collection took place in Summer 2020 academic semester. 55 responses were recorded, of which 50 could be included for analysis. The 50 participants included in the study completed all demographic information and all study measures.

[1] Eligible participant number reported as of January 2022. Prolific continually updates number of eligible participants on their website.

Consent was obtained via digital consent form prior to study commencement (Appendix A). Average completion time was 12-15 minutes and all participants received compensation of £2.92 ($5). Participant information is provided in Table 1.

Table 1

Phase 1 Demographic Characteristics of Participants

Sample Characteristics	*n*	%	*M*	*SD*
Age (years)			34.18	5.06
Location				
United Kingdom	30	60%		
Canada	4	8%		
Poland	4	8%		
United States of America	3	6%		
Others (Netherlands, Ireland, Sweden, France, Belgium, Mexico)	9	18%		
Race/Ethnicity (includes multiple responses)				
White	42	84%		
Unknown	4	8%		
Bi-racial	2	4%		
Others (Arab, Latin American)	2	4%		
Number of Children (Includes multiple responses)				
One	17			
Two	31			
Three	2			
Ages of Children				
First Child			5.36	1.54
Second Child			4.03	2.40
Third Child			3	2.83
DA-Kind Ownership (includes multiple responses)				
Amazon Alexa	37	47%		
Google Assistant	18	23%		
Apple Siri	15	19%		
Other (Samsung Bixby, MS Cortana)	8	11%		
DA Length Ownership				
Less than 1 year	8	16%		
1 year to 2 years	28	56%		
More than 2 years	14	28%		

Note. N=50

Procedure (Phase 1 Survey)

The survey was hosted on Survey Monkey, an online survey platform. Participants were recruited via Prolific, an online survey participant recruitment website that connects researchers and eligible research participants. Study details with the purpose of the study and requirements were advertised on Prolific (Appendix B). Eligible participants registered on Prolific received an invitation to take the survey on the Survey Monkey website. Confidentiality of responses was maintained through Survey Monkey response IDs and Prolific participant IDs. Once participants consented to the survey details and completed their responses, they were re-directed back to Prolific to record their completion. Participants were compensated through the prolific platform.

Materials and Measures (Phase 1 Survey)

The survey relies on participant self-reporting for response collection. Specifically, parents are asked to comment on their own DA use as well as on behalf of their children. Given the young ages of children involved as well as the pivotal role that parents play in promoting and mediating technology use (L. Clark, 2011; Jiow et al., 2017; Livingstone & Helsper, 2008; Plowman et al., 2008), parental reports are expected to be a crucial source of information.

The survey consisted of a mix of open-ended and close-ended questions (Appendix C). Close-ended questions primarily related to demographic information and questions relating to DA ownership and frequency of use. These questions were presented to participants in the form of multiple-choice options. Open ended questions related to DA use, popular information and knowledge queries, and how children relate and interact with DAs. These questions were presented to participants in the form of numbered free-text textboxes (e.g., List 5 ways you use your DA). The measures are described in detail below.

Digital Assistant Ownership Measures

Digital Assistant Type. The type of digital assistant(s) used in the home was assessed by a single multiple-choice question *What type of digital assistant/smart speaker do you use at home? (Check all that apply) [Options: Google Assistant, Amazon Alexa, Apple Siri, Samsung Bixby, Microsoft Cortana]*. This question identifies which commercial DAs are being used at home and analyze any usage patterns as a function of device type (e.g., music more common on Apple HomePod versus Amazon Alexa). These categories reflect the most used DAs across the Western world (Olson & Kemery, 2019).

Digital Assistant Ownership Duration. How long participants have owned their digital assistants was assessed by a single multiple-choice question, *how long have you owned your digital assistant/smart speaker? [Options: Less than 6 months, 6 months to 1 year, 1 year to 2 years, more than 2 years]*. This question allows us to understand whether responses are being given by novice users or more experienced users. Further, this question is expected to reflect global device adoption and usage patterns (Pew Research Center, 2017)

Digital Assistant Use Measures

Frequency of Use. DA use frequency was measured by a single multiple-choice question**,** *how often do you and your family engage with your digital assistant/smart speaker? [Options: Daily; multiple queries, daily: 1-2 queries, Once every few days, A few times a week, Rarely]*. This question focusses on frequency of usage and allows us to understand how embedded DAs are in everyday family life (Beneteau et al., 2020; Garg & Sengupta, 2020) and how much children are potentially exposed to these devices on a daily basis.

Range of Parent Uses. Range of DA uses for parents was measured by a single open-ended question, *what are different ways that you use your digital assistant/smart speaker at home? List at least 3 ways below (e.g., Knowledge search, weather queries etc.).* This open-ended question allows participants to list up to five ways that they use their DAs at home. It allows for participants to list top-of-mind categories in their own words.

Range of Children Uses. *Range of DA uses for children was measured by a single open-ended question, what are different ways that your children use your digital assistant/smart speaker* *at home? List at least 3 ways below (*e.g., *Knowledge search, weather queries etc.).* This question is similar to the previous question but centers on parental reports of children's use of DAs. Participants can list up to 5 ways that their children use DAs. It allows us to ascertain how children use DAs on a regular basis as well as how child use might differ from parent use.

DA Knowledge Search Topics Measures

Range of Parent DA Queries. Range of DA queries for parents was measured by a single open-ended question*, what kind of queries/questions do you ask your digital assistant/smart speaker? List at least three below.* This open-ended question allows participants to list the different kind of queries or questions they ask their DAs. DAs are voice-activated devices and rely on users to speak to the devices usually in the form of a command or question (Hoy, 2018). This question reveals the kinds of questions being asked of DAs and allows for further categorisation of responses based on kinds of DA queries. Given that information-based voice search is a key functionality of DAs (Hoy, 2018), the kinds of knowledge-based topics being searched with the device are of interest.

Range of Children DA Queries. Range of DA Queries for children was measured by a single open-ended question, *what kind of queries/questions do your children ask your digital assistant/smart speaker? List at least three below.* This question is similar to the previous question but centers on the kinds of questions that children ask DAs. This question allows us to understand the kinds of questions and queries being asked of the device as well as how children's responses may differ from parent questions. Children are known to be active question-askers (Lovato et al., 2019) and this question may provide critical insight into how they conceive of DAs, what they learn about the world from the DA and the limits of DA intelligence.

Examples of Child-DA Queries. Examples of child-DA queries were collected by a single open-ended question**,** *provide a few examples of queries that your children recently asked your digital assistant.* This question provides an opportunity for parents to provide a few real-world examples of queries that their children might ask their DAs. It provides an opportunity for parents to give authentic examples of real-world DA interactions.

Examples of Parent and Child DA Queries. Examples of queries used by parents and children together were collected by a single open-ended question, *provide a few examples of queries that you recently asked your digital assistant with your children.* This question provides an opportunity for parents to provide a few real-world examples of queries that parents may ask DAs with their children. It provides an opportunity for parents to give authentic examples of real-world DA interactions as well as examples of co-use of technology by parents and children (L. Clark, 2011)

Child-DA Interaction Measures

Range of Child-DA Interactions. Range of child-DA interactions was measured by a single open-ended question, *how do your children interact with your digital assistant/smart speaker? (*e.g., *You may comment on their conversation style, manner of interactions or any associated social behaviours)*. This open-ended question prompts participants to comment on how their children interact with DAs. Previous research has shown that children interact with DAs in noteworthy ways such as ascribing personality traits or human-qualities (Druga et al., 2017; Garg & Sengupta, 2020; Hoffman et al., 2021; Lovato et al., 2019) hence this question provides an opportunity to report their children's conversation style and interactions with the DA.

Child-DA Relationship Measure

Range of Child-DA Relationships. Range of descriptors of Child-DA relationship was measured by a single open-ended question, *How would you describe the relationship your children share with your digital assistant/smart speaker (if any)?* (e.g., transactional and enquiry-based, teacher, friend etc.). This open-ended question prompts participants to consider whether their children relate to DAs in any noteworthy ways. Previous research has indicated that children may view DAs in particular ways due to how they interact with devices and may even form emotional attachments (Garg & Sengupta, 2020; Purington et al., 2017). Given the voice-based capabilities of DAs that encourage interaction between users and the devices and resemble human conventions of speech (Hoy, 2018), how children interact with the device and what kind of relationship, if any, is shared between child and device is of interest.

Procedure (Phase 2 Measure Design)

DA Use

In Phase 1, participants were asked to list up to 5 ways (at least 3 ways) that they and their children use DAs at home. Responses were reviewed and two levels of codes were generated to categorise each response. Level 1 codes referred to general categories that the response belonged to and level 2 codes described level 1 codes in additional detail. For example, a participant response entitled “setting up alarms” was categorised as “Clock/Time” (Level 1) and “Set Alarm” (Level 2). Code names were based on analysing participant responses with the goal to create a unique and descriptive term to describe use.

A brief literature review was conducted of studies that either measured DA use directly or included a categorisation of DA uses (Bentley et al., 2018; Lopatovska et al., 2019; Lopatovska & Williams, 2018; Lovato et al., 2019; Lovato & Piper, 2015). Additionally, DA use categorization from commercial DA companies such as Amazon, Google and Apple were reviewed (Amazon

Help & Customer Service, n.d.; Apple Support, n.d; Google Assistant Help, n.d). Codes from Phase 1 data were then reviewed with categorisations seen in relevant studies and from commercial DA companies. Over 80 use categories from Phase 1 and the literature review were reviewed; the criteria for selecting final use categories included a) a reasonably high observed frequency (at least 10% of all uses) b) used in different studies, c) distinctiveness, and d) usefulness.

Knowledge Search Topics

In the Phase 1 survey, participants were asked to list up to 5 queries or questions (at least 3 queries or questions) that they and their children ask DAs. Responses were reviewed and codes were generated to categorise each response. For example, a participant response entitled "What films is this actor in" was categorised as "Media/Entertainment". Code names were based on analysing participant responses with the goal to create a unique and evocative term to describe the knowledge category.

A brief literature review was conducted of studies that either measured the kinds of information being searched with DAs directly or included a categorisation of Knowledge search topics (Festerling & Siraj, 2020; Lovato et al., 2019). Additionally, categorisations regarding information search used by commercial DA companies such as Amazon, Google and Apple were reviewed (Amazon Help & Customer Service, n.d.; Apple Support, n.d; Google Assistant Help, n.d). 50 knowledge search topics were reviewed and criteria for selection of final use categories included high observed frequency (at least 10% of all topics) in different studies, distinctiveness, and usefulness to the study.

Child-DA Interactions

In Phase 1, participants were asked to comment on how their children interact with their respective DAs. Responses were reviewed and codes were generated to categorise each response.

For example, a participant response “They often tease Alexa and ask her to tell jokes” was categorised as “Humorous” tone. Code names were based on analysing participant responses with the goal to create a unique and descriptive term to describe the tone category. Codes from Phase 1 data were then reviewed with related DA studies that considered child-DA interactions (Druga et al., 2017; Festerling & Siraj, 2020; Lovato et al., 2019). 25 relationship and personality characteristics and other descriptors of child-DA interactions were reviewed to arrive at final child-DA interaction categories. Selection criteria included high observed frequency in different studies (at least 19% of responses), distinctiveness, and usefulness to this study.

Child-DA Relationships

In Phase 1 survey, participants were asked to describe the relationship their children share with their DA, if at all. Responses were reviewed and codes were generated to categorise each response. For example, a participant response entitled “Like a useful friend” was categorised as “Friend”. Code names were based on analysing participant responses with the goal to create a unique and evocative term to describe the relationship category. Codes from Phase 1 data were then reviewed with related DA studies that considered child-DA relationships (Druga et al., 2017; Festerling & Siraj, 2020; Lovato et al., 2019). 25 relationship and personality characteristics and other descriptors of child-DA interactions were reviewed final child-DA relationship categories. Selection criteria included high observed frequency in different studies (at least 19% of responses), distinctiveness, and utility for the purposes of this study.

Results

Phase 1: Survey

In addition to owning one DA that was the study requirements, almost a third of participants reported that they owned 2 DAs (28%). In terms of device usage, most participants reported using their DAs daily, 42% of participants mentioned using their DA for multiple queries, and 34% of participants reported using their DA for 1-2 queries. A smaller percentage of participants indicated that they use their DAs less regularly, a few times a week (14%), once every few days (6%) and rarely (4%)

RQ1: What are the range of DA uses for families (parents and children) in the home?

Descriptive statistics from Phase 1 revealed ways that DAs are used by parents and children, which uses were more popular than others and whether there were any significant differences between how parents and their children use the device. Parents reported 226 uses and reported 174 uses for their children. Frequency analysis of DA use codes revealed parents and children use DAs in similar ways but in different amounts (Table 2). Overall, parents reported a broader range of DA uses than their children. The most frequently reported DA uses by parents were to conduct knowledge search, engage with different kinds of media, and check the weather, X^2 (11, 226) = 229.79, $p < .001$. In contrast, parents reported children use DAs most frequently for media and play, X^2 (8, 174) = 145.45, $p < .001$. Responses regarding DA uses were coded for uniqueness and utility. Generated codes from Phase 1 survey were collated with related research categorization and industry categorization to construct a DA use measure that captured a unique range of DA uses in the home (Table 2). To construct the measure, uses were compared across study 1, related DA studies and industry categories (Appendix D). The resulting measure (Appendix D) consists of 13 DA uses written as categories and requires participants to indicate their level of use using a Likert scale ranging from (Never, rarely or 1-2 times a week, sometimes or 3+ times a week, often or 1-2 times a day, and frequently or 3+ times a day). For example, participants are asked to indicate how often they use their DAs for “News” related functions.

Table 2
Digital Assistant Use Coding Scheme Development

Phase 1 Survey			
Code Name	Code Description	User	
		Parent	Child
Knowledge Search	Search and lookup different kinds of knowledge and information	26%	19%
Media/Entertainment	Play different kinds of media and entertainment	21%	28%
Weather	Search and lookup weather conditions in present and future	16%	6%
Clock/Time	Look up Date and Time related information	13%	6%
Play	Engage in play-related behaviours with child	8%	28%
Organizer	Organise day, life events and future tasks	6%	2%
Control House Devices	Remotely control various smart devices in house	6%	16%
Communication	Engage with phone functions for communication	1%	2%
Education	Play educational content with child	1%	3%
Other Categories [a]		1%	

Phase 2 Literature Review		
Code Name	Code Description	Source/Citation
News	Hear daily news, news briefings and related updates	Scuito et al. (2018), Lopatovska et al. (2019), Amazon Support, Google Support, Apple Support
Shopping and Delivery	Conduct e-commerce transactions, online shopping activities, food delivery or order a taxi	Scuito et al. (2018), Amazon Support, Google Support
Fitness and Wellness	Start a fitness routine, timed workout routine or guided meditation	Amazon Support
Finance	Conduct Financial transactions and look up personal financial information	Amazon Support

Note. Unique DA uses observed across parent and child responses from Phase 1 Survey. Parent responses = 226; Child responses = 174

[a] Represents categories that could not be coded either due to lack of information provided by participant or inapplicability of response

RQ2: What are the range of common knowledge-based topics that families (parents and children) search on their DAs?

Phase 1 survey results provide insights into the frequency of knowledge search topics and differences between parents and children (Table 3). Parents reported 157 queries and reported 164 queries for their children. Queries that were information-related or knowledge oriented were categorised as “Knowledge Search” topics (e.g., “What is the capital of Spain?”). 69 knowledge topics were further coded for Parents and 77 knowledge topics for Children. The most frequently reported knowledge search topics by parents were Media/Entertainment, Science, Currency conversion, and Product reviews, X^2 *(*13, 69) = 73.72, p < .001. In contrast, the most frequently reported knowledge search topics for children were about nature (e.g., order of the colors in the rainbow or what sounds different animals make) and idiosyncratic general knowledge questions (how many bricks in my house or whether werewolves are real), X^2 (11,77) = 58.77, p < .001. Generated codes from Phase 1 survey were collated with related research categorization and industry categorization to construct a DA knowledge search measure that captures a comprehensive and unique range of knowledge search topics searched on DAs in the home (Table 3). To construct the measure, knowledge or information categories were compared across Phase 1 and related DA studies and industry categories. The resulting measure (Appendix D) consists of 17 Knowledge-related topics written as categories and requires participants to indicate their frequency of search using a Likert scale ranging from (Never, rarely or 1-2 times a week, sometimes or 3+ times a week, often or 1-2 times a day, and frequently or 3+ times a day). For example, participants are asked to indicate how often they use their DAs to search for the topic “Sports and Sporting Events”.

Table 3

Digital Assistant Knowledge Search Coding Scheme Development

Phase 1 Survey			
Code Name	Code Description	User	
		Parent	Child
Celebrity	Queries about celebrities	6%	1%
General Knowledge	Queries about general information about the world	7%	22%
Language	Queries about languages	4%	4%
Media/Entertainment	Queries about media and entertainment	26%	10%
Nature	Queries about the natural world	4%	25%
Science	Queries about science	12%	8%
Digital Assistant	Queries about the digital assistant	1%	9%
Cooking	Queries about cooking recipes	4%	
Math conversions	Queries about unit conversions	9%	
Holidays	Queries about holidays	3%	
Maps	Queries about geography and maps	7%	
News	Queries about news and current affairs	7%	
Product Reviews	Queries about consumer products	9%	
Christmas	Queries about christmas and holidays		5%
Games	Queries about games		3%
Home/household	Queries about the home		6%
How-to	Queries regarding how-to do a task		1%
Math	Queries regarding math problems		5%
Phase 2 Literature Review			
Code Name	Code Description	Source/Citation	
Sports & Sporting Events	Queries about live sport games scores, sport news or sports information	Google Support	
Finance	Queries about economy, stock market information, stock prices	Amazon Support, Google Support	

Note. Unique DA knowledge-based queries observed across parent and child responses from Phase 1 Survey. Parent responses = 69; Child responses = 77

RQ3: What are the range of ways that children interact with DAs?

In Phase 1 Survey, almost half of parents (48%) indicated that their children were comfortable using basic function of DAs and a smaller subset of parents (20%) indicated that their children were still learning how to use DAs effectively. A third of parents (34%) indicated that their child thinks of DAs as a real living entity such as a human or animal. Parents indicated that their children take specific tones when speaking with DAs. Of these, most parents (25% of responses) indicated their children mimic their tone of voice while speaking with DAs, followed by adopting a conversational tone, humorous tone and shouting (each 19% of responses). Generated codes from Phase 1 survey were collated with related research categorization to construct a Child-DA tone measure that captured a comprehensive and unique range of tones that children might use when interacting with DAs in the home. The resulting measure (Appendix D) consists of 5 Child-DA Tones written as statements and requires participant to indicate their level of agreement with statements using a Likert scale ranging from (Strongly disagree, somewhat disagree, neither agree not disagree, somewhat agree, strongly agree). For example, participants are asked to indicate their level of agreement with the statement "My children adopt a formal and serious tone when using my digital assistant".

Table 4
Child-Digital Assistant Tone Coding Scheme Development

Code Name	Code Description	Reported Frequency
Commanding/bossy	Child uses a commanding tone when speaking with DA	6%
Conversational	Child uses a conversational tone when speaking with DA as if conversing with a person	19%
Humorous	Child uses a humorous tone of voice when speaking with DA	19%
Mimics Adult	Child mimics adult tone of voice when speaking to DA	25%
Polite tone	Child uses a polite tone of voice when speaking with DA	13%
Shouting	Child uses a shouting tone when speaking with DA	19%

Note. Unique Child-DA relationship codes observed across parent responses in Phase 1 Survey.

Parent responses =50

RQ4: What are the range of descriptions of child-DA relationships?

In the Phase 1 Survey, close to half of parents (44% of responses) reported that their children treated the DA in a transactional manner, i.e., interacting with the device only as and when they need to ask the device something. Despite this, a third of parents indicated that their children think of DAs as a friend, X^2 (8, 174) = 145.45, $p < .001$. Generated codes from Phase 1 survey were reviewed alongside related research categorization to construct a Child-DA relationship measure that captured a comprehensive and unique range of adjectives to describe how a child might think of a DA as well as how the relationship between children and DAs might be characterised (Table 5). The measure construction process compared relationship description categories across Phase 1 and related DA studies (Appendix D) The final measure (Appendix D) consists of 5 Child-DA relationship descriptions and 5 DA adjectives written as statements and requires participant to indicate their level of agreement with statements using a Likert scale ranging from (Strongly disagree, somewhat disagree, neither agree not disagree, somewhat agree, strongly agree). For example, for Child-DA relationships, participants are asked to indicate their level of agreement with the statement “My children have a friendly relationship with the digital assistant, as if it were a friend”. For DA adjectives, participants are asked to indicate their level of agreement regarding whether their children would use the adjective “Trustworthy” to describe their digital assistant.

Table 5

Child-Digital Assistant Relationship Coding Scheme Development

Phase 1 Survey		
Code Name	Code Description	Reported Frequency
Teacher like	Child relates to DA as a teacher or teaching device	4%
No relationship	Child and DA have no meaningful relationship	12%
Entertainer	Child considers DA as source of entertainment	6%
Comical	Child considers DA as a source of humor or comic relief	2%
Conversational	Child relates to DA as conversation partner	2%
Friend	Child relates to DA as a friend or confidant	30%
Transactional (Enquiry Based)	Child only interacts with DA when they need to ask DA about something	40%
Transactional (Task Based)	Child only interacts with DA when they need to accomplish a task	4%
Phase 2 Literature Review		
Code Name	Code Description	Source/Citation
Intelligent	Child considers DA to be intelligent or smart	Lovato et. al (2019), Druga et. al (2017)
Trustworthy	Child considers DA to be a trustworthy entity	Lovato et. al (2019), Druga et. al (2017)
Alive	Child considers DA to be a living entity	Festerling & Siraj (2020), Lovato et. al (2019)
Safe	Child considers DA to be a safe entity	Lovato et. al (2019)

Note. Unique Child-DA relationship codes observed across parent responses in Phase 1 Survey. Parent responses =50

Discussion

The goal of the study was to develop measures to understand DA use and child-DA interactions in the home. A global sample (n = 50) of parents, related studies in academic literature, and industry categorizations were reviewed to identify and list common uses, knowledge topics, and child-DA interactions and relationships.

First, the study identified the range of DA uses in the home, 10 uses were identified via the survey and an additional 4 were found in industry and literature reviews. These uses include knowledge search, media and entertainment, and clock/time related uses indicating families use

DAs for a broad range of tasks. Second, the study identified the range of DA queries. 18 knowledge topics were identified from the survey and an additional 2 were found in industry and literature reviews. These search topics include queries about science, nature and unit conversions indicating DAs are being used as knowledge devices. Third, this study identified the range of ways that children interact with DAs. Six tones or ways of speaking with DAs were identified from the survey. These tones include formal tones, conversational tones, or tones that mimic adult ways of speaking to the DA. Lastly, this study identified the range of descriptions of child-DA relationships. Eight child-DA relationships and DA adjectives descriptions were identified from the survey and an additional four descriptions were found in literature reviews. These descriptions include relationship descriptions such as “friend” or “teacher” and adjectives such as “trustworthy” or “alive”, revealing that children might relate to DAs in unique ways.

The categories identified in the study were then incorporated into new DA measures that can assess frequency of DA use, queries, and child-DA relationships across a broader sample of parents. For DA use, the measure contains one sub-scale with 13 items per scale. For DA knowledge queries, the measure contains one sub-scale with 17 items per scale. For Child-DA relationships, the measure contains 3 sub-scales with 5 items per scale. These measures assess how families use DAs in the home, the kinds of information they search with DAs and how children interact with and relate to DAs. Further, these measures provide a straightforward way to understand how DAs are being used in homes and the resulting quantitative data can facilitate meaningful comparisons between different kinds of groups (Parents, countries, SES factors, ages of children etc.). In summary, this study’s key finding is the creation of an assessment framework relating to DA use, knowledge-search as well as child-DA interactions and relationships. Overall, this study that will form a foundational basis of the next larger multi-national study of DA use.

Study 2: Multi-National Online Study

This study builds on study 1 by using its measures to explore DA use and child-DA interactions in a more fulsome way. This study is different from Study 1 (Phase 1) in three ways. First, it is a larger study focused on a wider sample (N = 300) from three countries, Canada, the United Kingdom, and United States of America. Second, survey questions use Study 1 measures, and its close-ended measures result in quantitative data on a full range of uses, search queries, child-DA interactions, and parental mediation strategies. Third, in addition to exploring DA use and child interactions, this survey also explores parental mediation of DA use. The guiding research questions are:

RQ1: How do families (parents and children) use DAs at home?

RQ2: How do children relate to DAs at home?

RQ3: What kind of strategies do parents use to mediate child DAs use?

Method

Participants

Participants consisted of 300 English-speaking parents of children (ages 4-8 years), who have a smart speaker/DA in their homes, from 3 countries–Canada, USA and the UK (100 participants each). Participants who had taken part in the first pilot study were excluded from the study. Prior to data collection, ethics approval was obtained from the McGill Research Ethics Board. The survey was hosted on Qualtrics, an online survey platform. Participants were recruited via Prolific, an online survey participant recruitment website that connects researchers and eligible research participants. Study details with the purpose of the study and requirements (Appendix E) were advertised on Prolific. Participants were randomly selected out of eligible participant pools in the three respective countries, ~2949 (UK), ~216 (Canada) and ~1952 (USA)[2]. An estimated 348 responses were received, of which 300 could be included in analysis. The 48 responses that were not included in the study included Do-Not-Consent (5), duplicate entries (7), attention check failures (20) and partial completions (16). The 300 participants included in the study completed all demographic information and study measures. Consent was obtained via digital consent form prior to study commencement (Appendix F). Average completion time was 15-30 minutes and all participants received compensation of £5.85 ($10). Participant information is provided in Table 6.

Table 6

Study 2 Demographic Characteristics of Participants

Sample Characteristics	*n*	%	*M*	*SD*
Gender				
Women	199	66.3%		
Men	101	33.7%		
Age			34.64	5.44
Race/Ethnicity (includes multiple responses)				
White	250	83.3%		
Black or African American	13	4.3%		
Chinese	12	4%		
South Asian	11	3.7%		
Others (Indigenous, Latin American etc.)	28	9.2%		
Number of Children (aged 4-8 yrs)				
One	223	74.3%		
Two	74	24.7%		
Three	3	1%		
DA-Kind Ownership (includes multiple responses)				
Amazon Alexa	203	67.7%		
Google Assistant	130	43.3%		
Apple Siri	102	34%		
Other (Samsung Bixby, MS Cortana)	30	10%		
DA Length of Ownership				
More than 2 years	199	66.3%		
Less than 2 years	101	33.6%		

Note. N=300

[2] Eligible participant number reported as of January 2022. Prolific continually updates number of eligible participants on their website.

Procedure

Eligible participants registered on Prolific received an invitation to take the survey on the Qualtrics website. Confidentiality of responses was maintained through anonymized Qualtrics response ID and Prolific participant IDs. Once participants consented to the survey details and completed their responses, they were re-directed back to Prolific to record their completion. Apart from responses questions, the survey also included of 9 attention checks interspersed throughout the survey. If participants failed 3 or more attention checks, they were not compensated for the survey. Participants who failed 2 attention checks or less and successfully completed the survey were compensated through the prolific platform.

Materials and Measures

Similar to Study 1 (Phase 1), this survey relies on parental reports. Parents report family DA use, both for themselves and on behalf of their children. In addition to DA use and interactions, parents reported the parental mediation strategies they employ for DAs in their home. The survey consisted of only close-ended questions (Appendix G), wherein questions were presented to participants in the form of multiple-choice options. These questions generated quantitative data to facilitate statistical analysis.

The survey was divided into 5 sections and administered in the following order: Demographic Information, DA Ownership, DA Usage Measures, Parental Mediation Measures and DA Relationship Measures. DA ownership questions related to the commercial brand of DA owned by participants (e.g., Amazon Alexa), duration of ownership, and type of DA (e.g., Smart speaker), which is presented alongside the demographic information in Table 6 above

DA Use Measure

Frequency of DA Use. A frequency measure developed in Study 1 was used to assess which DA uses were more frequent than others for parents and children. The DA use measure consisted of 13 uses; for each use, frequency of use was measured with a 5-point Likert scale ranging from *Never* to *Frequently (3+ times a day)*.

Independent Interactions between Child-DA. Independent interactions was measured by a single multiple-choice question*, how often do your children independently interact with your DA?* **[***Options: Never, rarely, sometimes, often, frequently]* This question helps to identify whether DA use is usually facilitated in group family settings or whether children interact with the device by themselves. Previous research has indicated that DA use can often take place in familial settings and that adult use of DAs is different from child use (Beneteau et al., 2020; Garg & Sengupta, 2020).

Child's comfort with using DA. Children's comfort with using DAs was measured by a single multiple-choice question*, how comfortable are your children with using your DA?* [*Options: Extremely uncomfortable, uncomfortable, neither comfortable nor uncomfortable, comfortable, very comfortable]*. This question establishes how comfortable children are with the functionalities and features of DAs. Previous studies have shown that children gain comfort with technology by observation, trial and error and modelling of their parents (Plowman et al., 2008) hence this question explores how competent young children are with DAs.

DA Knowledge Search Topics Measure

Frequency of Knowledge-Search Topics. A frequency measure of DA Knowledge-Search topics developed in Study 1 was used to assess which knowledge-based topics are more frequently searched for than others by parents and children. Overall, the DA Knowledge Search

Topics measure consists of 17 Topics; for each topic frequency of search was measured using a 5-point Likert scale ranging from *Never* to *Frequently (3+ times a day)*

DA Information Reliability Measures

Parent Information Reliability. Parent's view of DA information reliability was assessed through a single multiple-choice question, *How reliable do you think your digital assistant is as an information source? [Options: extremely reliable, reliable, neither reliable nor unreliable, unreliable, extremely unreliable]*. This question was included to explore attitudes towards information reliability of DAs. A key issue that emerges is how the information is presented to users such that users feel satisfied with responses provided and so that information provided is fair and not grounded in misinformation (Stucke & Ezrachi, 2017)

Child Information Reliability. Children's view of DA information reliability was assessed through a single multiple-choice question, *according to your children, how reliable do you think your digital assistant is as an information source? [Options: extremely reliable, reliable, neither reliable nor unreliable, unreliable, extremely unreliable]*. This question is a follow-up from the previous question and explores children's attitudes to the information they receive from DAs. Through this question, not only are children's attitudes towards DA's information reliability assessed but also whether their attitudes closely match parental attitudes. Previous research has indicated that children can be influenced not only by how their parents use the technology at home (Plowman et al., 2008) but also parental perceptions of risks of technology (Livingstone et al., 2017; Livingstone & Helsper, 2008)

Child-DA Association Measures

Child-DA Tone. A measure to assess how parents describe the tone with which children speak to DAs was used. The measure, developed in Study 1, consisted of 5 DA tone descriptors wherein statements regarding Child-DA tone descriptors were presented to participants, and they were asked to report their level of agreement on a 5-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*.

Human or Machine. Children's conceptions of DAs as human or machine-like was assessed through two multiple-choice questions. The measure consisted of 2 statements presented to participants. These statements were–participants' children interact with DAs as if the DA was human and that children interact with DAs as if the DA was a machine. Participants were asked to report their level of agreement on a 5-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*.

Child-DA Relationship. A measure to assess how parents describe child-DA relationships developed in Study 1 was utilized. The measure consisted of 5 DA relationship descriptors. Participants were presented with statements regarding Child-DA relationship descriptors, and they were asked to report their level of agreement on a 5-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*.

Child-DA Adjective. A measure to assess adjectives that children might use to describe DAs developed in Study 1 was utilized. The measure consisted of 5 DA adjectives. Participants were presented with statements regarding adjectives their children might use to describe their DA, and they were asked to report their level of agreement on a 5-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree*.

Parental Mediation Measures

Given the pivotal role that parents can play in mediating the use of different kinds of media at home (L. Clark, 2011; Jiow et al., 2017; Livingstone et al., 2017; Livingstone & Helsper, 2008), the survey included a measure to understand parental mediation as it relates to DA use. Currently, there are no established parental mediation measures catered to DA use in the home. Hence, Livingstone et al., (2017) parental mediation measure on internet use was adapted for DA use (Appendix D). Livingstone et al. (2017) internet parental mediation measure included 6 scales– active mediation of Internet use, child-initiated support, active mediation of Internet safety, parental monitoring, technical controls, and parental restrictions. Each scale measures the frequency or occurrence of a particular parental mediation activity.

Parental Mediation of DA Use Measure. In order to adapt the parental mediation of internet use (Livingstone et al., 2017) for DA use, each item under the 6 scales was reviewed for appropriateness and relevancy. Of the 50 items in the original Livingstone et al. (2017) parental mediation measure, 26 items were adapted into the DA use parental mediation measure. Each item was updated with relevant DA language and context. 4 items from technical controls scale and 3 items from parental monitoring scale were not readily adaptable to DA use due to mismatch in capabilities between DAs and internet (e.g., parents are not able to check social media profiles of their children on a DA). Additionally, for child-initiated support, an additional item was added regarding whether DAs understood a child's request, as previous research has indicated that DAs sometimes struggle to process children's voices correctly (Cheng et al., 2018; Sciuto et al., 2018) For the parental restrictions scale, rather than using the 17 items from Livingstone et al. (2017) scale on parental restrictions, the 13 DA use categories developed and described in the previous section were used for assessing parental restrictions. As participants responded to how frequently their children used their DA for a specific function, they were asked to indicate level of parental restriction. If participants indicated that their children never used the DA for a particular function, such as "Finance", they were prompted to choose between two options to indicate reason–either due to lack of parental allowance or due to lack of interest from child. When participants indicated their children used the DA for a particular function, they were prompted to choose between two options to indicate parental restriction–either their children could use the function whenever they wanted or they could do so only under parental supervision. This question resulted in a scale of DA restriction ranging from 0 to 2 (0 indicating no restriction or lack of interest, 1 indicating some restriction under supervision and 2 indicating maximum restriction of use or use forbiddance)

Results

In this section, several data analysis are presented with key data assumptions and reporting conventions. For repeated measures ANOVAs, when the data failed to meet the assumption of Sphericity, Greenhouse-Geisser correction was used to correct for the violation. Pairwise comparisons with Bonferroni corrections were used to identify differences among the 5 DA adjectives. Significance is set at 0.05 level and exact *p* values are reported when pairwise differences are made. For Chi Square goodness of fit tests, significant tests are reported and interpreted with standardized residual scores. Standard residual scores were calculated for each response item and scores above absolute (+/-) 2 are interpreted as contributing to the significance of the overall omnibus test (Sharpe, 2015).

RQ1: How do families (parents and children) use DAs at home?

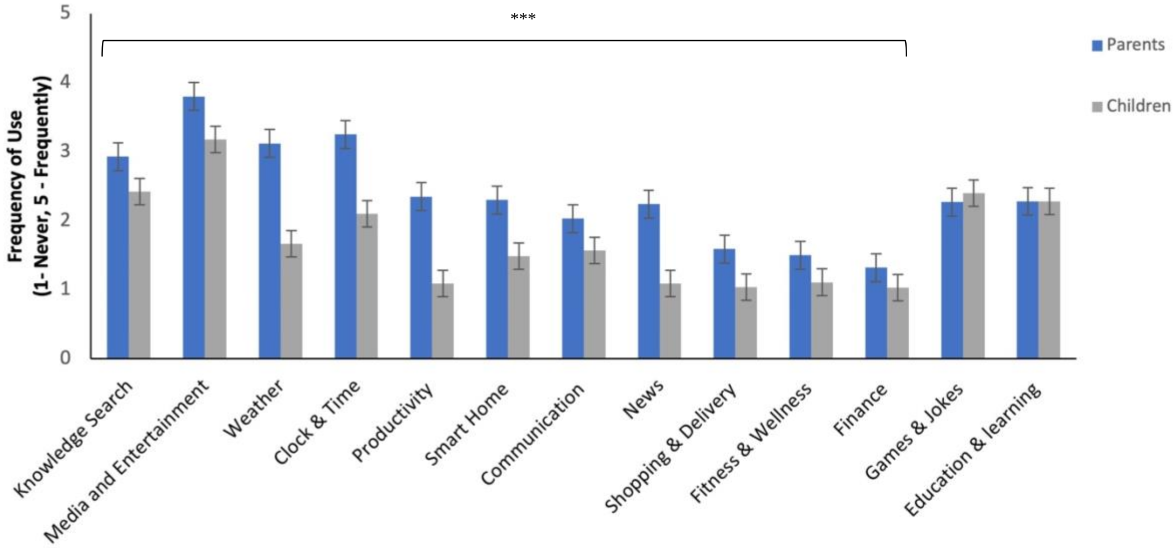
To understand how DAs are used at home by parents and children, the survey data was analyzed in the following ways. DA use assessed the frequency of 13 common DA uses, child-DA interaction frequency and child comfort with using DAs. Knowledge topics measure assessed the frequency of 17 popular knowledge topics. DA information-reliability questions explored parent and child attitudes towards DA information reliability. Multiple exploratory factor analysis were conducted on questionnaire items relating to DA use and DA knowledge topics measures to identify underlying commonalities. Survey questions regarding children's independent interactions with DAs, children's comfort with using DAs and information reliability were analyzed with Chi Square goodness of fit tests.

Digital Assistant Use

To investigate DA use, a 2 (User: Parent, Child) X 13 (Use) repeated-measures within-subjects ANOVA was conducted on parent's reported frequency of use. There was a main effect of User, F (1, 299) = 613.83, MSE = 1.37, p <0.001, η_p^2 = 0.67. Overall, Parents reported higher DA use for themselves (M = 2.38) than their children (M = 1.73). There was also a main effect of Use, F (7.81, 2335.55) = 252.24, MSE = 1.62, η_p^2 = 0.46, p <0.001. Lastly, there was a significant User X Use interaction, F (9.23, 2759.36) = 69.36, MSE = 0.65, η_p^2 = 0.19, p <0.001. User pairwise differences revealed significant differences between a majority of DA uses (11 out of 13). Only Games and Jokes and Education and Learning categories were not significantly different between parents and children (Figure 2). For Parents, the most popular uses were Media and Entertainment (M = 3.80), Weather (M = 3.12), Clock & Time (M = 3.25), and Knowledge Search (M = 2.93), For children, the most popular uses were Media & Entertainment (M = 3.18), Games & Jokes (M = 2.40), Knowledge Search (M = 2.42), and Education & Learning (M = 2.23).

Figure 2

Frequency of DA Use for Parents and Children



Note. Error bars represent standard errors. ***difference between parent and child uses significant $p < 0.001$

Two exploratory factor analysis (EFA) using varimax rotation were conducted on Parents and Children's DA use. EFA analysis identifies underlying factor structures amongst survey questionnaire items and provides a way to group similar items (Watkins, 2018). In this case, similar DA uses can be grouped together by identifying latent constructs that influence similar DA use items. Different factor structures emerged for Parents (Table 7) and Children (Table 8). The factor analysis revealed a two-factor structure for parents accounting for 52.85% of total variance and a three-factor structure for children accounting for 53.21% of total variance, which is an acceptable threshold range for variance explained in social science research (UCLA: Statistical Consulting Group, n.d.)

Table 7

Results from Factor Analysis of DA uses for Parents

DA Use category	Factor Loading	
	1	2
Factor 1: Undifferentiated		
Games & Jokes	**0.43**	0.42
Productivity	**0.54**	0.42
Communication	**0.59**	0.36
Education & Learning	**0.63**	0.42
News	**0.53**	0.46
Shopping & Delivery	**0.79**	0.24
Fitness & Wellness	**0.68**	0.14
Finance	**0.84**	0.08
Factor 2: Information about World and Home		
Knowledge Search	0.20	**0.63**
Media & Entertainment	0.10	**0.50**
Weather	0.18	**0.68**
Clock & Time	0.17	**0.56**
Smart Home	0.20	**0.23**

Note. N = 300. The extraction method was principal axis factoring with an orthogonal (Varimax with Kaiser Normalization) rotation. Factors loadings are in bold.

Table 8

Results from Factor Analysis of DA uses for Children

DA Use category	Factor Loading		
	1	2	3
Factor 1: News, Commerce & Self-Improvement			
Productivity	**0.68**	0.10	0.28
News	**0.67**	0.14	0.23
Shopping & Delivery	**0.58**	0.14	0.12
Fitness & Wellness	**0.54**	0.22	0.04
Finance	**0.59**	-0.01	-0.03
Factor 2: Learning, Entertainment & Communication			
Knowledge Search	0.11	**0.58**	0.41
Media & Entertainment	0.07	**0.34**	0.16
Games & Jokes	0.09	**0.73**	0.11
Communication	0.23	**0.40**	0.28
Education & Learning	0.16	**0.79**	0.13
Factor 3: Life & Home Utilities			
Weather	0.11	0.20	**0.66**
Clock & Time	0.70	0.26	**0.68**
Smart Home	0.12	0.06	**0.17**

Note. N = 300. The extraction method was principal axis factoring with an orthogonal (Varimax with Kaiser Normalization) rotation. Factors loadings are in bold.

Children's Independent Interactions with DA. A chi-square goodness of fit test on this survey items responses revealed that responses were not due to chance, X^2 (4, 300) = 53.37, p <0.001 with most individual responses received exceeding the acceptable standardised residual cut-off of absolute 2. Some parents indicated that their children interact with their DA, either 1-2 times a day (26%), which was greater than expected due to chance (standardized residual >2) or more than 3 times a day (12.3%) which was lesser than expected due to chance (standardized residual <-2). Further, some parents (29.33%) indicated that their children sometimes interacted with their DA, i.e., more than 3 times a week which was greater than expected by chance (standardized residual >2). Some parents (24.67%) reported that their children rarely interacted with their DA, i.e., 1-2 times a week however this was not different than expected by chance. A small percentage (7.67%) of parents indicated that their children never independently interact with DAs and this was lesser than expected due to chance (standardized residual <-2)

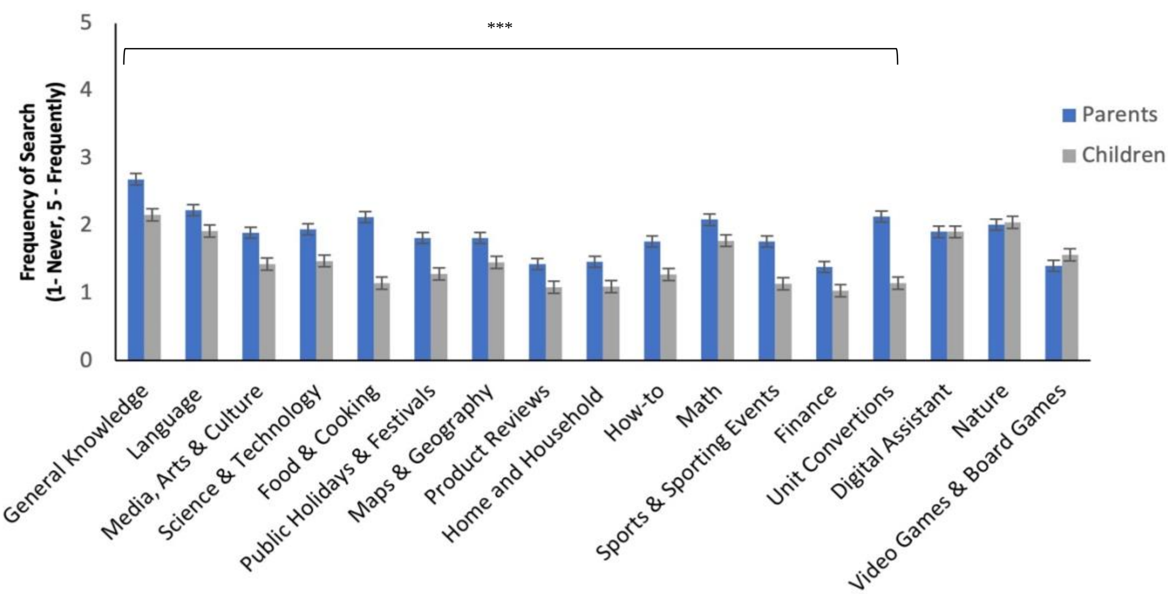
Children's comfort with using DA. A chi-square goodness of fit test on this survey items responses revealed that responses received were not due to chance, X^2 (4, 300) = 205.9, p <0.001 with most individual responses received exceeding the acceptable standardised residual cut-off of absolute 2. Almost half of parents (47.67%) indicated that their children were "somewhat comfortable" with using a DA, which was higher than expected by chance (standardized residual >2). Almost a third of parents (30%) indicated that their children were "extremely comfortable" using a DA, which was higher than expected by chance (standardized residual >2). A smaller percentage of parents indicated that their children were "somewhat uncomfortable" (9.67%) and extremely comfortable with using DAs (2.67%), which were both less frequent than expected by chance (standardized residual <-2). Some parents reported that their children were neither comfortable nor uncomfortable using a DA (10%), which was lesser than expected by chance (standardized residual <-2).

Knowledge Search Topics

To investigate knowledge search topics, a 2 (User: Parent, Child) X 17 (Knowledge Search Topic) repeated-measures within-subjects ANOVA was conducted on parent's reported frequency of Knowledge Search Topics (KST). There was a main effect of User, F (1, 299) = 290.41, MSE = 1.44, p <0.001, η_p^2 = 0.49, Overall, Parents reported higher KST frequency for themselves (M = 1.89) than their children (M = 1.48). There was also a main effect of KST, F (10.15, 3033.46) = 99.39, MSE = 0.98, η_p^2 = 0.25, p <0.001. Lastly, there was a significant User X KST interaction, F (11.79, 3525.91) = 38.78, MSE = 0.44, η_p^2 = 0.12, p <0.001. User pairwise differences revealed significant differences between a majority of DA KSTs (14 out of 17). KST frequency for Nature, Digital Assistant and Video Games & Board Games were not significantly different between parents and children (Figure 3). For Parents, the most popular KSTs were General Knowledge (*M* = 2.70), Language (*M* = 2.23), Unit Conversions (*M* = 2.14) and Food & Cooking (*M* = 2.13), For children, the most popular KSTs were General Knowledge (*M* = 2.16), Nature (*M* = 2.05), Language (*M* = 1.92), and Digital Assistant (*M* = 1.91).

Figure 3

Frequency of Knowledge search Topics for Parents and Children



Note. Error bars represent standard errors. ***difference between parent and child search topics significant $p < 0.001$

To identify commonalities amongst KSTs, two exploratory factor analysis (EFA) using varimax rotation were conducted on Parents and Children's DA use. Here, similar knowledge topics can be grouped together by identifying latent constructs that influence the same DA knowledge topics. Different factor structures emerged for Parents (Table 9) and Children (Table 10). The factor analysis revealed a three-factor structure for parents accounting for 60.42% of total variance and a three-factor structure for children accounting for 61.91% of total variance, which exceeds the threshold range for variance explained in social science research (UCLA: Statistical Consulting Group, n.d.)

Table 9

Results from Factor Analysis of Knowledge Search Topics for Parents

DA Use category	Factor Loading		
	1	2	3
Factor 1: Undifferentiated			
Media Arts & Culture	**0.52**	0.49	0.16
Public Holidays & Festivals	**0.51**	0.31	0.33
Maps & Geography	**0.51**	0.31	0.40
Product Reviews	**0.71**	0.31	0.27
Video Games & Board Games	**0.66**	0.35	0.02
Home & Household Activities	**0.59**	0.26	0.33
How-to	**0.60**	0.32	0.42
Sports & Sporting Events	**0.51**	0.15	0.25
Finance	**0.65**	0.17	0.20
Factor 2: Information Seeking			
General Knowledge	0.30	**0.68**	0.17
Language	0.20	**0.67**	0.34
Nature	0.18	**0.68**	0.26
Science & Technology	0.44	**0.58**	0.29
Digital Assistant	0.31	**0.41**	0.05
Factor 3: Measurements			
Food & Cooking	0.39	0.30	**0.46**
Math	0.25	0.36	**0.44**
Unit Conversions	0.20	0.18	**0.79**

Note. N = 300. The extraction method was principal axis factoring with an orthogonal (Varimax with Kaiser Normalization) rotation. Factors loadings are in bold.

Table 10

Results from Factor Analysis of Knowledge Search Topics for Children

DA Use category	Factor Loading		
	1	2	3
Factor 1: Undifferentiated			
Food & Cooking	**0.72**	0.29	0.09
Public Holidays & Festivals	**0.54**	0.42	0.18
Unit Conversions	**0.65**	0.40	0.03
Product Reviews	**0.62**	0.13	0.47
Home & Household Activities	**0.70**	0.17	0.17
How-to	**0.49**	0.29	0.33
Sports & Sporting Events	**0.68**	0.15	0.19
Finance	**0.73**	0.03	0.10
Factor 2: Learning & Education			
General Knowledge	0.09	**0.74**	0.27
Language	0.18	**0.73**	0.22
Nature	0.20	**0.72**	0.16
Science & Technology	0.40	**0.69**	0.02
Digital Assistant	0.20	**0.45**	0.33
Maps & Geography	0.40	**0.60**	0.17
Math	0.27	**0.64**	0.27
Factor 3: Entertainment			
Media Arts & Culture	0.23	0.31	**0.48**
Video Games & Board Games	0.22	0.30	**0.67**

Note. N = 300. The extraction method was principal axis factoring with an orthogonal (Varimax with Kaiser Normalization) rotation. Factors loadings are in bold.

DA Information Reliability

A chi-square goodness of fit test on this survey item's response (Parent-DA information reliability) revealed that responses were not due to chance, X^2 (3, 300) = 375.44, p <0.001 with all individual responses received exceeding the acceptable standardised residual cut-off of absolute 2. More participants reported that they find their DA "reliable" (72.67%), which was higher than expected by chance (standardized residual >2) and "extremely reliable" (10%) as an information source, which was lesser than expected by chance (standardized residual <-2). A smaller number of participants reported that their DA is neither reliable nor unreliable (15.67%), which was lesser than expected by chance (standardized residual <-2), and “unreliable” (1.67%) as an information source, which was lesser than expected by chance (standardized residual <-2). No participants reported that their DA was extremely unreliable as an information source.

A chi-square goodness fit test on this survey item’s responses (Child-DA information reliability) revealed that responses received were not due to chance, X^2 (4, 300) = 207.47, p <0.001, with most individual responses received exceeding the acceptable standardised residual cut-off of absolute 2. In contrast to parents, a higher percentage of participants reported their children find DA “extremely reliable” (38%) followed by “reliable” (37.33%) and “neither reliable nor unreliable” (23.33%), which were all higher than responses expected by chance (standardized residual >2), A small percentage of participants reported that their children find their DA unreliable (0.67%) and extremely unreliable (0.67%) which were both which was lower than expected by chance (standardized residual >2)

RQ2: How do children relate to DAs?

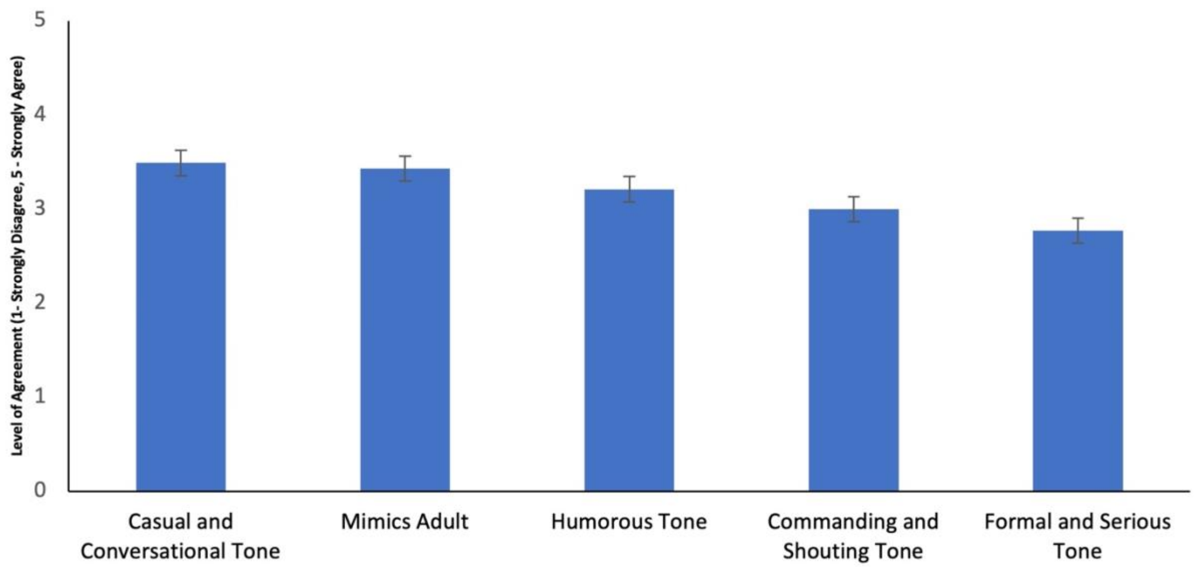
To understand how children understand and relate to DAs, the data was analysed in the following ways. DA Tone measure assessed the frequency of 5 voice-tones that children might use with DAs, the human or machine measure assessed whether children interact with DAs as if DAs are human-like or machine-like, Child-DA relationship measure assessed the frequency of 5 kinds of relationships that children might share with DAs and Child-DA adjective measure assessed the frequency of 5 adjectives children might use to describe DAs.

Tone Descriptions

To investigate the tones that children use while addressing DAs, a repeated-measures ANOVA was conducted on the level of agreement of 5 Tone descriptions. There was a main effect of DA Tones. F (3.40, 1014.96) = 21.02, MSE = 1.54, p < 0.001, η_p^2 = 0.07. Pairwise comparisons revealed significant differences between some descriptors but not between all five. Parents were more likely to report that their children would "Mimic Adult" tone (*M* = 3.43) and use "Casual and Conversational" tone (*M* = 3.49), however these tones were not significantly different from each other (p >0.05). Following these, the next highest rated tone was "Humorous" tone (*M* = 3.21) and "Commanding and Shouting" Tone (*M* = 3.0), however they were not significantly different from each other ($p > 0.05$). The lowest rated tone description was "Formal and Serious" tone (*M* = 2.77) which was significantly different from all other tones except for "Commanding and Shouting" tone.

Figure 4

Level of Agreement regarding DA Tone Descriptions



Note. Error bars represent standard errors.

Human or Machine Measure

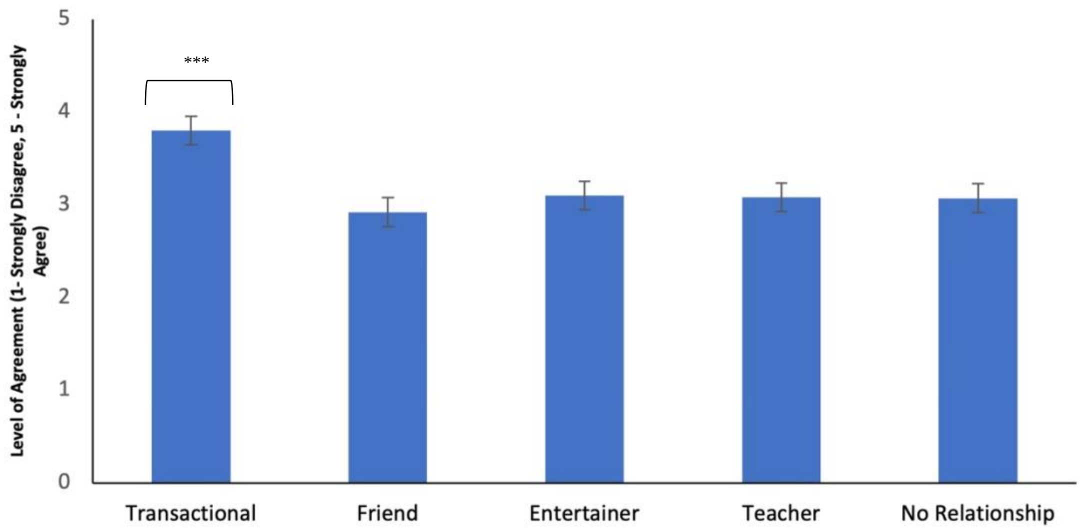
A paired sample *t*-test was conducted to understand whether children consider a DA more human-like or more machine-like as an entity. Parents reported that their children considered their DA to be more machine-like (*M* = 3.54, *SD* = 1.03) than human-like (*M* = 2.97, *SD* = 1.22), $t(299) = 4.86$, $p < 0.001$.

Child-DA Relationships

To investigate Child-DA relationships, a repeated-measures ANOVA was conducted on the level of agreement on the 5 relationship descriptors. There was a main effect of relationship description, F (3.06, 913.87) = 21.22, MSE = 2.23, p <0.001, η_p^2= 0.07. Pairwise comparisons revealed significant differences between the descriptor "Transactional" and other descriptions but not between the other 4 descriptions. Hence parents described child-DA relationships most often as "Transactional" (M = 3.80)

Figure 5

Level of agreement regarding Child-DA relationship Adjectives



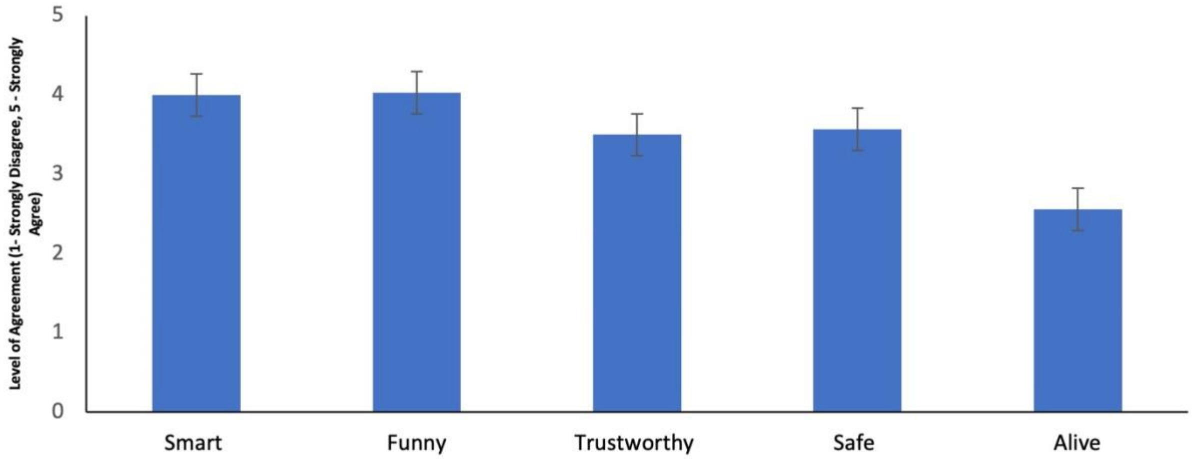
Note. Error bars represent standard errors. ***difference between relationship adjectives significant $p < 0.001$

Child-DA Adjectives

To investigate how children might conceive of DAs as an entity, a repeated-measures ANOVA was conducted on the level of agreement on the 5 DA adjectives. There was a main effect of DA adjective. F (3.23, 965.51) = 145.04, MSE = 0.91, p < 0.001, η_p^2 = 0.33. Pairwise comparisons revealed significant differences between some descriptors but not between all five. The highest rated adjectives, "Smart" (M = 4.0) and "Funny" (M = 4.03) were significantly different from the other 3 adjectives (p<0.001) but were not significantly different from each other. The next highest reported adjectives were "Safe" (M = 3.57) and "Trustworthy" (M = 3.50), however they were not significantly different from each other (p > 0.05). The lowest reported adjective was "Alive" (M = 2.56), which was significantly different from all other adjectives.

Figure 6

Level of Agreement regarding DA Adjectives



Note. Error bars represent standard errors.

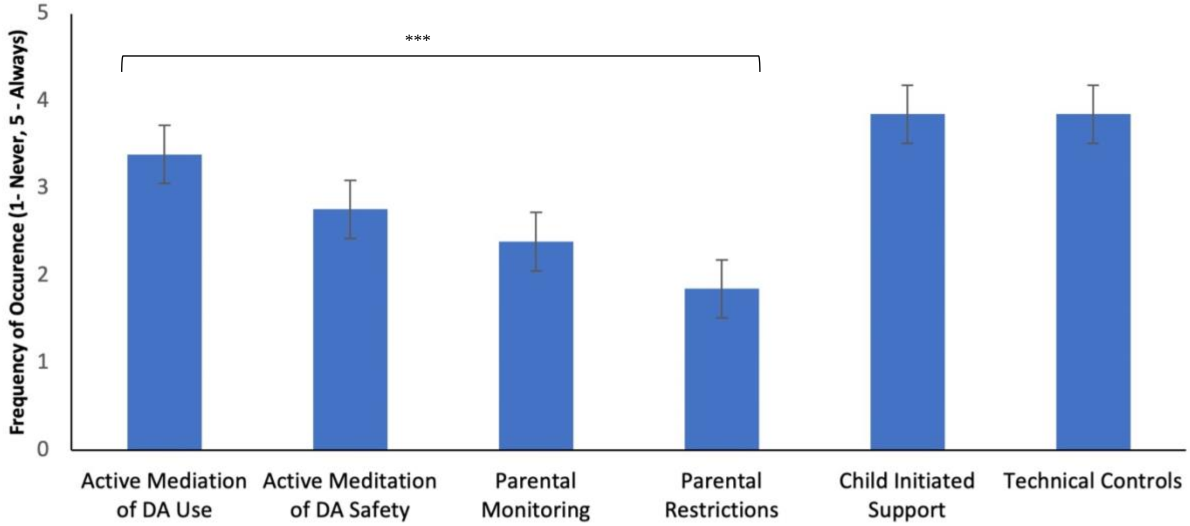
RQ3: What kind of strategies do parents utilize to mediate the use of DAs for their children?

To understand the frequency of parental mediation of DA use, a repeated-measures within-subjects ANOVA was conducted on parent's reported frequency of 6 parental mediation strategies. Following Livingstone et al., (2017) categorization used in their factor analysis, mediation strategies for DA use were grouped into five enabling strategies (Active mediation of DA use, Child Initiated Support, Active mediation of DA safety, Technical Controls, and Parental Monitoring) and one restrictive strategy (Parental Restrictions)

There was a main effect of mediation strategy, F (2.93, 868.99) = 201.90, MSE = 1.69, p <0.001, η_p^2 = 0.41 (see Figure 7). Pairwise comparisons revealed significant differences among most parental mediation strategies for DA use (4 out of 6). Child initiated support (M = 3.85) and Technical Controls (M = 3.85) did not differ from each other and were significantly different than all other strategies, which did significantly differ from each other. Overall, enabling strategies, comprised of active mediation of DA use (*M* = 3.39), Child Initiated Support (*M* = 3.85), Active mediation of DA safety (*M* = 2.77), Technical controls (*M* = 3.85), and Parental Monitoring (*M* = 3.39), were more used than restrictive strategies (*M* = 1.86).

Figure 7

Frequency of Parental Mediation Strategies for DA Use

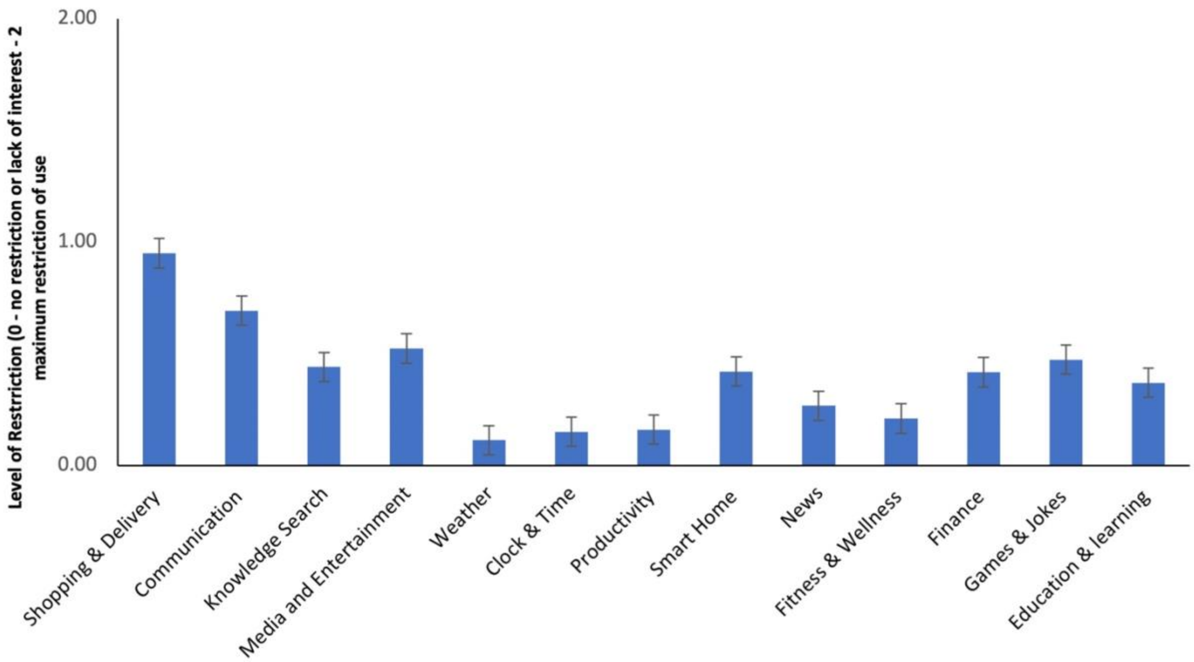


Note. Error bars represent standard errors. ***difference between mediation strategies significant $p < 0.001$

To understand parental restrictions in detail, a repeated measures within-subjects ANOVA was conducted on reported restriction levels for all 13 DA uses. There was a main effect of restriction level, F (6.90, 2061.52) = 51.54, MSE = 0.56, p <0.001, η_p^2 = 0.15 (see Figure 8). Pairwise comparisons revealed significant differences between some DA uses. The DA uses that were most restricted by parents were Shopping and Delivery (*M* = 0.95), Communication (*M* = 0.69), which were significantly different from all other uses. On the other hand, the DA uses that were least restricted by parents were Weather (*M* = 0.11), Clock and Time (*M* = 0.15) functions, productivity functions (*M* = 0.16), News (*M* = 0.27), and fitness functions (*M* = 0.21) that were significantly different to all other uses but not different from each other, whereby children were able to use DAs with limited parental restrictions or were not interested in these functions.

Figure 8

Level of Parental Restrictions for DA Uses



Note. Error bars represent standard errors.

Discussion

This study aimed to provide a perspective on critical aspects of DA use and interaction across three large western countries. Utilizing frameworks to measure DA use, knowledge search, parental mediation, and child-DA interactions developed from the previous study and adapting established frameworks for DAs, the study provides novel insights into the role of DAs in the home.

Parents and children reported using DAs in distinct ways, with parents reporting higher use of DAs than children. In line with advertised affordances of DAs and prior research (Ammari et al., 2019; Garg & Sengupta, 2020; Hoy, 2018; Maedche et al., 2019), parents and their children leverage DAs extensively for media and entertainment purposes such as playing music, videos, podcasts, and storybooks. After media and entertainment, parents use DAs for more straightforward utility-oriented functions, such as looking up weather conditions and clock functions for timers or alarms. On the other hand, children's other top uses are knowledge search, games and jokes, and education and learning. These uses are learning and play-oriented functions observed in related research (Bailey et al., 2021; Garg & Sengupta, 2020a; Lovato et al., 2019; Oranç & Ruggeri, 2021). Notably, the nature of these DA functionalities and their task performance may influence how children view the technology as a presence in the home. Prior research has shown that DA's ability to understand requests, complete tasks successfully and showcase subject matter knowledge often influences children's conceptions of the DA as intelligent or friendly (Druga et al., 2017; Garg & Sengupta, 2020; Lovato et al., 2019; Sciuto et al., 2018). Factor Analysis revealed underlying constructs that grouped similar DA uses. For Parents, DA uses can be grouped into uses that provide information about the home and world or are undifferentiated. For children, DA uses can be grouped into three kinds of uses-: 1) uses that relate to news, commerce, and self-improvement, 2) uses that relate to learning, entertainment, and communication, and 3) uses that relate to life and home utilities. Overall, the factor analysis reveals two insights regarding DA use at home. First, parents and children use the same DA in different ways at home, as seen in previous research (Garg & Sengupta, 2020; Lovato & Piper, 2015). Second, the factor groupings indicate that there are also differences present in kinds of uses. While parents may use DAs for more utility-oriented functions to gain knowledge about the world and their homes, children may be more interested in the full range of uses that DAs might support, as seen in their varied factor groupings. These findings also align with prior research that children may explore different kinds of DA commands than their parents and use ones that their parents do not regularly use (Garg & Sengupta, 2020).

Regarding how children interact with DAs, around a third of parents in the survey reported that their young children interact with them more than once a day and are comfortable doing so. This will no doubt allow this generation of children to be uniquely comfortable with voice-based technology (Grudin, 2008) and provide young children a head start in learning technology-use conventions, such as how to phrase a search query. Further, these frequent interactions may influence a child's ToAM (Bharadwaj et al., in press) of their DA. For instance, A child may begin to ascribe beliefs and intentions to the DA through observing how the DA behaves in different situations (e.g., setting an alarm to telling them a story) and the limits of its capabilities (e.g., when the DA cannot correctly respond to a request).

Regarding knowledge search topics, parents and children reported searching for similar topics. Further, a majority of parents and children view information received from DAs to be reliable. This suggests that parents and children may have similar ToAM conceptions regarding DAs and their capabilities. General knowledge was a popular area of search for both parents and children, which included searches for general information about the world. Parents' top knowledge searches included questions about language, such as word meanings and definitions and unit conversions across different measurement systems. For children, top knowledge searches included language and questions about the natural world and the digital assistant itself. Knowledge search topics indicate that children are learning about the world around them, within the home and outside of it, through the DA. Factor Analysis revealed underlying constructs that grouped similar DA knowledge search topics from responses. For parents, knowledge topics could be grouped into undifferentiated topics, information-seeking topics, and measurement-related topics. For children, knowledge topics could be grouped into undifferentiated topics, learning and education topics, and entertainment-related topics. These findings align with previous research indicating that children enjoy searching for science-related topics with DAs (Lovato et al., 2019; Oranç & Ruggeri, 2021). In order to understand how children learn DA affordances, the children possessing similar patterns of use and attitudes as their parents may provide insight. Given that more than half of participants reported that their children independently interact with DAs less than once a day, most knowledge searches with the device might be taking place with parents and children together. This might explain why knowledge search topics between the groups are more similar than DA uses and that children may learn DA affordances from joint interactions with their parents.

Children relate to DAs in unique and interesting ways. While parents reported that their children view their relationship with DAs as transactional and machine-like, they also reported that their children would use human-like adjectives to describe DAs, such as “Smart” or “Funny”. These findings are in line with findings from previous research that suggest that children ascribe personality traits to DAs (Druga et al., 2017; Garg & Sengupta, 2020; Hoffman et al., 2021; Lovato et al., 2019) and may also develop emotional attachments with DAs (Hoffman et al., 2021). An open question is how children understand the mechanisms that support the functioning of DAs (e.g., Internet search engines such as Google or Bing that provide answers to queries) and whether they demonstrate any computational understanding (Wing, 2008) of DA or AI systems. Children speak to DAs in a wide range of tones, from conversational to formal and serious. In line with previous research indicating that parents frequently model behaviours for the use of technology with their children (Plowman et al., 2008) and earlier presented findings that parents and children are interacting with the device together, parents also reported that their children often mimic their ways of interacting with DAs. Considering how children conceive of DAs, how they use the device, and perceive its affordances (Norman, 1999) may ultimately influence how they regard the device. Given that popular DA uses for children include knowledge search and games, and jokes, it may influence how children come to view these devices as intelligent or humorous. Further, with child-focused features and designs (e.g., Amazon Echo Dot Kids Edition), DAs are also positioned to young children as friendly and helpful entities. Hence, as seen in other research focused on children's interactions with technology (Dubé & McEwen, 2017), children's perceived affordances of DAs will likely be influenced not only by observing parents use the device and modeling behaviours but also by their own prior experiences with the device.

Parental mediation measure provides fresh insights into the role of parents as it relates to DA use. Previous research suggests that parents play an important role in introducing the device to their children and helping them use it successfully (Beneteau et al., 2020; Cheng et al., 2018; Garg & Sengupta, 2020b). In addition to the introduction to the technology, parents also use a wide range of strategies to mediate the use of technology at home (L. Clark, 2011; Jiow et al., 2017; Livingstone & Helsper, 2008) and the study of DA use offers new ways to consider how intelligent technologies are jointly used and regulated in the home, particularly as they are communal devices. Popular parental mediation strategies for DA use include the use of technical controls, such as content blocking and filtering, and child-initiated support whereby a child seeks advice or help from parents. Following Livingstone et al. (2017) categorization of enabling versus restrictive strategies, enabling strategies that promote the use of DAs at home were more used than restrictive mediation strategies. Furthermore, child-initiated support indicates increased agency with which children can explore intelligent technologies as they can proactively learn about the device rather than being formally taught how to use it (Livingstone et al., 2017), and this is a top strategy used by parents in this study. While parents seem to play a role in how DAs are used by their children, more passive strategies (Technical Controls) and Child-led strategies were more popular than proactive or parent-led mediation strategies. As expected, parents restrict DA functions that pose more threat to their children, such as exposure to commercial activities or communication functions over others that may seem more harmless such as weather and clock functions.

Limitations and Future Directions

The two conducted studies reveal new insights regarding the role of DAs in homes across three large industrialized western countries. However, limitations regarding study methodology and scope exist that influence how far results can be applied to broader contexts. First, the studies primarily relied on self-report data and recall regarding DA use. While this provides a glimpse of how DAs are used in the home, it may not provide the same precision that log and user tracking data might provide. Parry et al. (2021) found that self-report data only moderately correlates to log data with digital media use and may not always be entirely accurate and advise that self-report data must be interpreted with caution. Second, parents provided reports of their children's DA use and conceptions of DAs, and as such, there is limited direct access to children and their understanding of AI systems. Additionally, given that children may use DAs independently without their parent's supervision, there might be further insights on child-DA interactions that parents have not been able to provide in the conducted studies. Lastly, the studies were conducted remotely using the participant recruitment website Prolific. While open to a vast participant pool, there was an overrepresentation of certain societal groups (e.g., white participants and female participants) in responses. Hence, while findings are certainly noteworthy, relevance to all societal groups and nations worldwide should be considered with caution.

Future research can augment present study findings in a few ways. First, speaking with children directly through interviews will provide valuable insight into how children conceive of

DAs. This project's future plans include direct observation of interactions between children and DAs to foster authentic explorations of children’s ToAM. It is important to consider how children begin to conceive about AI entities at a young age and how these conceptions evolve as they develop in childhood and adolescence. Second, a focus on information trust and verification. Given the voice-based nature of information presentation and popular uses of DAs include information and knowledge search, it will be important to investigate how children verify the information they receive from DAs. Lastly, exploring more global patterns of child-DA interactions. While this study focused on three western countries, ownership of DAs is also significant in other parts of the world. Given this, it will be interesting to consider the cultural nuances of child-DA interactions and what societal and individual factors contribute to children’s ToAM.

Conclusion

With the introduction of sophisticated AI technology and its growing presence in nearly every facet of human life in the twenty-first century, a continued examination of the implications of technology adoption is called for. Digital assistants are becoming a ubiquitous feature of human lives in the western world (Canalys, 2020) and boast an ever-increasing set of functions and features (Hoy, 2018). Due to their unique capabilities as a knowledge device (Hoy, 2018; Lovato et al., 2019; Bailey et al., 2019), DAs have the potential to impact many aspects of human learning and development. Further, the physical placement of DAs in the domestic sphere (Cain, 2022) and their proximity to young developing children (Friedman & Hendry, 2019) necessitate the study of how DAs are used and interacted with within the home.

The complex nature of this subject matter has encouraged an interdisciplinary approach. Moving beyond disciplinary silos allows us to generate new insights into this novel technology. Theories and approaches from developmental psychology, philosophy, computer science, and artificial intelligence have guided the current research project. DAs have been studied from three perspectives. First, from the perspective of the technology itself, its underlying AI capabilities, and general affordances. Second, from the young child's perspective and their developing mental and social capabilities. Third, from the parents' perspective and how they might influence and mediate the use of technology in the home. Taken together, it provides a comprehensive picture of DA technology and its use in the home.

Based on results from the present study and prior studies from the literature review, parents and children in western developed countries use DAs extensively for various tasks. DAs are a unique type of device resistant to any single use or type classification, as they support a wide array of functions from entertainment to learning to more ordinary time-keeping tasks. In line with how some commercial DA manufacturers envisioned the embedding of DAs in daily lives (Perez, 2021; Cain, 2022), families rely on DAs daily and for different needs. As children grow up around these devices, it impacts how they view the device and the world around them. Children appear to ascribe interactive DAs with human-like qualities and may go on to develop relationships with these devices. Parents' mediation strategies indicate that they are mostly comfortable with their children's use of DAs, enable their continued use, and let their children come to them to troubleshoot DA use.

An important takeaway message from this research is that DAs are being used as learning devices in the home, much like previous research has described (Garg & Sengupta, 2020; Lovato et al., 2019; Oranç & Ruggeri, 2021). Knowledge search is a popular use category for both parents and children, and DAs are used to search a diverse range of topics. For children, given that knowledge search and education are popular uses of DAs and are not heavily mediated or restricted by parents, it will be necessary to investigate further how children learn from DAs. Further, how children verify and accept information from DAs is vital to consider and relates to ongoing issues with information verifiability with internet technologies. Despite access and exposure to these technologies, young people can still struggle to correctly evaluate the veracity of the information they find online (McGrew et al., 2018). With a high prevalence of internet technologies that support easy access to information, information literacy or the ability to evaluate information critically is a key 21st-century skill (Voogt & Roblin, 2010). Questions posed to DAs can be answered in different ways. For example, DAs may answer directly to the user (e.g., the weather conditions or country capitals), DAs may consult a user-generated community database like Alexa Answers, where humans answer questions, or DAs may consult ranked web-search engines like Google or Microsoft Bing and retrieve top-ranked results. More idiosyncratic questions are often met with creative answers, such as when Apple Siri is asked whether Santa Claus is real, one of its programmed answers states, "Well, those cookies don't eat themselves." Some studies have shown that younger children are more hesitant to trust the information from DAs than older children (Druga et al., 2017). In contrast, others have shown that younger generations like GenZ trust DAs more than older generations (Noah & Sethumadhavan, 2019). For children, an important question is how they process and verify the information they receive from DAs and whether they take responses at face value. More recently, Girouard-Hallam and Danovitch (2022) found that children's trust in DAs varied with age and by type of information involved (Factual or personal information), suggesting that children's understanding of and trust in the informant grew more nuanced with age. This finding of selective trust in kind of information could have implications for the factor structures observed in children’s knowledge searches discussed earlier (e.g., entertainment topics could be trusted differently from education & learning topics). Overall, given the extensive presence of DAs globally, these findings could have broad implications for how generations of children are developing with sophisticated technology around them.

As discussed previously, the subsequent stages of this research project will focus on live interactions between children and DAs to directly observe how children understand the functioning of DAs, how they interact with DAs, and whether they develop socio-cognitive mechanisms such as Theory of Mind regarding artificial agents, as they do for human agents. Ultimately the goal of this research project is two-fold. First, to contribute to the generation of new knowledge on the impact of novel AI-powered technologies on human life and child development. Second, to inform parents and societal stakeholders such as educators and policymakers about the technology to empower them to make relevant decisions about technology use. Children today are growing up around technology that has become a fixture in the home and can begin using devices that require little to no training to use (Grudin, 2008) as soon as they gain basic linguistic functions. This could have wide-ranging impacts on the learning and development of children that are currently unknown. Hence, research into DAs must continue, and insights regarding user behavior must be available to the public, not just remain with commercial technology companies such as Amazon or Google. Understanding the multiple facets of technology use in society and providing these insights to the public will go a long way to support informed decision-making about technology.

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Appendix A
Study 1 Participant Consent Form

McGill
Department of
Educational and Counselling Psychology
in the Faculty of Education
Département de
psychopédagogie et de counseling
de la Faculté des sciences de l'éducation

Title of Study: "Ok Google, how tall is the sky?" How parents and children use digital assistants (i.e., smart speakers) at home.

Principal Investigator: Professor Adam K. Dubé
adam.dube@mcgill.ca
Assistant Professor, Learning Sciences Program
Department of Educational & Counselling Psychology
McGill University

Sponsors: Social Science and Humanities Research Council

Research Team: Adam Dubé, PhD; Victoria Talwar, PhD; Elizabeth Patitsas PhD; Nandini Asavari Bharadwaj (Research Assistant)

Purpose of the Study: Embedding computers and the internet in everyday objects has resulted in connected and interactive homes. Parents can lock their doors, dim the lights, ask if the fridge is out of milk and order more, all with their voice during family dinner. While this may seem futuristic, 46% of adults use digital assistants and Amazon reports selling over 100 million Alexa digital assistants across thousands of form factors. The connected home environment of today's child begs the question of how the use of digital assistants will shape children's beliefs of how intelligent technologies function (i.e., theory of artificial minds) and influence how children evaluate information learned from these knowledge objects (i.e., Pennycook & Rand, 2018).
The proposed research will detail how parents and children use intelligent technologies in the home with the long-term goal of identify whether parents and children's use of digital assistants to conduct everyday knowledge search (e.g., 'Alexa, who is the president of the USA?') affects children's ability to identify false information learned online.

Participants: You are being asked to participate in the study because you have a digital assistant in your home, and you are a parent of a child 4-8 years of age.

Procedures: If you agree to participate in this study, you will complete an online survey consisting of 11 questions about the use of digital assistants in your home as well as some demographic questions (age, # of children). The questions include: what type(s) of digital assistant(s) are in your home; how do you and your child use your digital assistant in your home; and what type of questions do you and your child ask your digital assistant in your home (e.g., child asking "Ok Google, how tall is the sky?). The study will take approximately 10 minutes to complete and does not require any follow-up participation. *This study has been reviewed and approved for ethical compliance by the McGill University Research Ethics Board.* General results will be made available to you on request.

Benefits of Participation: Possible benefits from study participation include an opportunity to reflect on how you and your children use digital assistants in your home.

Risks of Participation: There are no risks associated with participating in this study.

Cost /Compensation: Participants will receive appropriate compensation for their participation.

Contact Information/Questions: If you have any questions or concerns about the study, you may contact the Principle Investigator, Professor Adam K. Dubé (teklrncog@gmail.com).
If you have any ethical concerns or complaints about your participation in this study and want to speak with someone not on the research team, please contact the McGill Ethics Manager (lynda.mcneil@mcgill.ca; 514-398-6831) referencing REB # **19-12-010**

Voluntary Participation: Your participation in this study is voluntary. You may refuse to participate in this study, and you may withdraw from the study at any time without prejudice to your relations with the university. You are encouraged to ask questions about this study at any time prior to or after the study via email. If you choose to withdraw during or right after the study, all information obtained up until that point will be destroyed unless you specify otherwise at the time of withdrawal. Once data has been de-identified or combined for publication, it may not be possible to withdraw your data in its entirety. We can only remove it from analysis and from use in future publications. Identifiable data will be kept for 7 years.

Confidentiality: Your participation and answers will be confidential. All digital records will be saved in password encrypted files in a locked facility at McGill University for at least 7 years following study completion at which time it will be destroyed. In the event that data is destroyed before 7 years, participants will be informed. Access to participants' data will be limited to members of the research laboratory of Professor Adam K. Dubé and the research team listed above.
Please click type 'I CONSENT' below if you have read the above information and consent to participate in this study. Agreeing to participate in this study does not waive any of your rights or release the researchers from their responsibilities. A copy of this consent form will be given to you and the researcher will keep a copy.

Appendix B
Study 1 Participant Recruitment using Prolific

"Ok Google, how tall is the sky" How parents and children use digital assistants (i.e. smart speakers) at home

We are recruiting parents of children between 4-8 years of age who have a digital assistant in their homes to participate in a research study by Technology, Learning and Cognition Lab at McGill University. Our study aims to identify how parents and children use intelligent technologies in the home. The long-term goal is to identify whether parents and children's use of digital assistants to conduct everyday knowledge search affects children's ability to identify false information learned online. The survey includes 11 questions about smart speakers and should take less than 15 minutes to complete.

Devices that can participate in study: Mobile, Tablet and Desktop

Study Link: (Link to Study hosted on Survey Monkey)

Recruit Participants: 50

Location: All countries available

Payment provided: $CAD 5

Appendix C
Study 1 Survey Questions

1. Please click "yes" below if you have read the above information and consent to participate in this study

   Yes
   No

2. I confirm that I am a parent of at least one child 4 to 8 years of age

   Yes
   No

3. What is your Prolific ID? (Textbox)
4. What is your age in years? (Textbox)
5. What is your place of residence? (Textbox)
6. What is the highest level of school you have completed or the highest degree you have received? (Choose one)

   Primary School
   High school degree or equivalent (e.g., GED)
   CEGEP or college degree
   Bachelor/ Trade/ Technical degree
   Graduate degree
   Other (please specify)

7. What is your race/ethnicity? (Textbox)
8. What is your yearly household income in Canadian currency? (Choose one that applies)

   Less than $20,000
   $20,000 to $34,999
   $35,000 to $49,999
   $50,000 to $74,999
   $75,000 to $99,999
   $100,000 to $149,999
   $150,000 to $199,999
   $200,000 or more

9. How many Children do you have? (Textbox)
10. Please write the ages of each of your children below

    Age of Child 1
    Age of Child 2
    Age of Child 3

11. What type of digital assistant/smart speaker do you use at home? (Check all that apply)

Google Assistant
Amazon Alexa
Apple Siri
Samsung Bixby
Microsoft Cortana

12. How long have you owned your digital assistant/smart speaker? (Choose one)

Less than 6 months
6 months to 1 year
1 year to 2 years
More than 2 years

13. How often do you and your family engage with your digital assistant/smart speaker? (Choose One)

Daily, multiple queries
Daily, 1-2 queries
Once every few days
A few times a week
Rarely

14. What are different ways that you use your digital assistant/smart speaker at home? List at least 3 ways below (E.g., Knowledge search, weather queries etc.) (Textbox)
15. What are different ways that your children use your digital assistant/smart speaker at home? List at least 3 ways below (E.g., Knowledge search, weather queries etc.) (Textbox)
16. What kind of queries/questions do you ask your digital assistant/smart speaker? List at least three below (Textbox)
17. What kind of queries/questions do your children ask your digital assistant/smart speaker? List at least three below (Textbox)
18. How do your children interact with your digital assistant/smart speaker? (E.g., You may comment on their conversation style, manner of interactions or any associated social behaviours) (Textbox)
19. How would you describe the relationship your children share with your digital assistant/smart speaker (if any)? (E.g., transactional, and enquiry-based, teacher, friend etc.) (Textbox)
20. Provide a few examples of queries that your children recently asked your digital assistant (Textbox)
21. Provide a few examples of queries that you recently asked your digital assistant with your children (Textbox)

Appendix D
Study 1 Measures

DA Use Measure Development

Codes	Code Descriptions	Example Command	Source
Knowledge Search	Search and lookup different kinds of knowledge and information	"<Digital Assistant wake word>, what is the capital of Norway?"	1, 2, 4, 5, 6, 7, 8
Media & Entertainment	Play different kinds of media and entertainment such as music, videos, podcasts, audiobooks, storybooks	"<Digital Assistant wake word>, play One More Time by Daft Punk"	1, 3, 4, 5, 6, 7, 8
Weather	Look up weather conditions in past, present and future	"<Digital Assistant wake word>, what is the weather today?"	1, 3, 4, 5, 6, 7, 8
Clock & Time	Look up date and time, set a timer or alarm, use stopwatch	"<Digital Assistant wake word>, set a timer for 10 minutes"	1, 3, 4, 5, 6, 7, 8
Games & Jokes	Play fun activities such as games, jokes, humorous noises	"<Digital Assistant wake word>, tell me a joke"	1, 3, 5, 6, 7
Productivity	Manage tasks and organize life with calendar, map directions, shopping lists, reminders, emails	"<Digital Assistant wake word>, add orange juice to my shopping list"	1, 3, 4, 5, 6, 7, 8
Smart Home	Control and find smart devices in house such as security devices, lights, thermostat, plugs, cameras, vacuums, and other connected devices	"<Digital Assistant wake word>, switch on the lights"	1, 3, 4, 5, 6, 7, 8
Communication	Make phone or video calls and use as intercom	"<Digital Assistant wake word>, call mom"	1, 3, 6, 8
Education & Learning	Play learning content such as word of the day, this day in history, spelling and vocabulary activities, Wikipedia searches	"<Digital Assistant wake word>, teach me about potatoes"	1, 6
News	Hear daily news, news briefings, flash news briefing and related updates	"<Digital Assistant wake word>, tell me the news"	3, 5, 6, 7, 8
Shopping & Delivery	Conduct ecommerce transactions, online shopping activities, food delivery, order a taxi	"<Digital Assistant wake word>, call me an uber"	3, 6, 7
Fitness & Wellness	Start a fitness routine, timed workout and guided meditation	"<Digital Assistant wake word>, set a meditation timer"	6
Finance	Conduct financial transactions and lookup personal financial information	"<Digital Assistant wake word>, what's my credit card balance?"	6

Note. Table Legend 1: McGill Team; 2: Lovato & Piper (2015); 3: Scuito et. al. (2018); 4: Bentley et. al. (2018); 5: Lopatovska et al. (2019), 6: Amazon Support; 7: Google Support; 8: Apple Support

Study 2 DA Use Measure

Categories	Descriptions	Frequency Scale 1: Never – 5: Frequently (3+ times a day)
Knowledge Search	Search and lookup different kinds of knowledge and information	
Media & Entertainment	Play different kinds of media and entertainment such as music, videos, podcasts, audiobooks, storybooks	
Weather	Look up weather conditions in past, present and future	
Clock & Time	Look up date and time, set a timer or alarm, use stopwatch	
Games & Jokes	Play fun activities such as games, jokes, humorous noises	
Productivity	Manage tasks and organize life with calendar, map directions, shopping lists, reminders, emails	
Smart Home	Control and find smart devices in house such as security devices, lights, thermostat, plugs, cameras, vacuums, and other connected devices	
Communication	Make phone or video calls and use as intercom	
Education & Learning	Play education and learning content such as word of the day, this day in history, spelling and vocabulary activities, Wikipedia searches	
News	Hear daily news, news briefings, flash news briefing and related updates	
Shopping & Delivery	Conduct ecommerce transactions, online shopping activities, food delivery, order a taxi	
Fitness & Wellness	Start a fitness routine, timed workout, and guided meditation	
Finance	Conduct financial transactions and lookup personal financial information	

DA Knowledge Search Topics Measure Development

Coded Categories	Code Descriptions "Queries relating to..."	Example Commands	Source
General Knowledge	General information about the world	"<Digital Assistant wake word>, "How tall is the tallest person to have lived?"	1, 2
Language	Word meanings, definitions, spellings, translations	"<Digital Assistant wake word>, how do you spell commemorate?"	1, 2, 3, 5
Media, Arts and Culture	Celebrities, TV and films, Arts and media	"<Digital Assistant wake word>, who directed Citizen Kane?"	1, 3
Nature	Natural world, animals, plants	"<Digital Assistant wake word>, how long does an Octopus live for?"	1
Science and Technology	Science news, scientific explanations, technology updates	"<Digital Assistant wake word>, who invented the internet?"	1, 3
Digital Assistant (DA)	DA personality, DA thoughts, DA behaviours, DA features	"<Digital Assistant wake word>, how are you today?"	1, 3
Food and Cooking	Recipes, cooking times, cuisine information	"<Digital Assistant wake word>, how do I make rice?"	1
Public Holidays & Festivals	Holiday dates, holiday significance, holiday history	"<Digital Assistant wake word>, why is Diwali celebrated?"	1
Maps & Geography	World geography, Map information, Place and Distance information	"<Digital Assistant wake word>, how far away is New Zealand?"	1
Product Reviews	Technology reviews, product reviews	"<Digital Assistant wake word>, give me a review of the latest iPhone"	1
Video Games and Board Games	Video games, board games, gameplay information, game tutorials, release dates	"<Digital Assistant wake word>, how do you play monopoly?"	1
Home & household activities	Home activities, household schedules and routines	"<Digital Assistant wake word>, when is dinner scheduled?"	1, 4, 5
How-to	How to perform a particular task, guidance on tasks	"<Digital Assistant wake word>, how do you clean an oven?"	1, 2, 4, 5
Math	Calculations, quick math problems, math guidance	"<Digital Assistant wake word>, what is the square root of 72?"	1, 2, 3, 4, 5
Sports & Sporting Events	Sporting games scores, Sport news, sports information	"<Digital Assistant wake word>, tell me the cricket scores"	5
Finance	Economy information, Stock market information, stock prices	"<Digital Assistant wake word>, what is the stock price of Shopify?"	4, 5
Unit Conversions	Converting units across measurement systems	"<Digital Assistant wake word>, what is 5km in miles?"	1, 2, 3, 4, 5

Note. Table legend 1: McGill Team; 2: Festerling and Siraj (2020); 3: Lovato et. al. (2019); 4: Amazon Support; 5: Google Support

Study 2 DA Knowledge Search Topic Measure

Categories	Descriptions	Frequency Scale 1: Never – 5: Frequently (3+ times a day)
General Knowledge	General information about the world	
Language	Word meanings, definitions, spellings, translations	
Media, Arts and Culture	Celebrities, TV and films, Arts, and media	
Nature	Natural world, animals, plants	
Science and Technology	Science news, scientific explanations, technology updates	
Digital Assistant	Digital assistant personality, Digital assistant thoughts, Digital assistant behaviours, Digital assistant features	
Food and Cooking	Recipes, cooking times, cuisine information	
Public Holidays & Festivals	Holiday dates, holiday significance, holiday history	
Maps & Geography	World geography, Map information, Place and Distance information	
Product Reviews	Technology reviews, product reviews	
Video Games and Board Games	Video games, board games, gameplay information, game tutorials, release dates	
Home & household activities	Home activities, household schedules and routines	
How-to	How to perform a particular task, guidance on tasks	
Math	Calculations, quick math problems, math guidance	
Sports & Sporting Events	Sporting games scores, Sport news, sports information	
Finance	Economy information, Stock market information, stock prices	
Unit Conversions	Converting units across measurement systems	

Child-DA Relationship Measure Development

Categories	Source
Relationship	
Teacher	1
No observed relationship	1
Entertainment or Entertainment Provider	1, 4
Friend	1, 2, 3, 4
Transactional (Enquiry Based)	1
Adjective	
Intelligent	3, 4
Trustworthy	3, 4
Alive	2, 3
Safe	3
Funny or Humorous	3
Tone	
Commanding/bossy	1
Conversational Tone	1, 2
Humorous	1, 3
Mimics adult tone	1
Polite	1

*Note***.** Table Legend 1: McGill Team; 2: Festerling and Siraj (2020); 3: Lovato et. al. (2019); 4: Druga et. al. (2017)

Study 2 Child-DA Relationship and Interaction Measures

Measures and Items	Agreement Scale (1: Strongly disagree – 5: Strongly agree)
Child-DA Relationships (*Indicating whether children treats DA in the ways mentioned below)*	
Treat DA as Human-like	
Treat DA as machine-like	
Transactional relationship	
Friend or friendly relationship	
Entertainer	
Teacher or information source	
No Relationship	
DA Adjectives (*Indicating whether child would use below adjectives to describe DA)*	
Smart	
Trustworthy	
Alive	
Safe	
Funny	
Tone Descriptions (*Indicating tone used by children when speaking with DA)*	
Mimic Parent’s tone of speaking with DA	
Formal and Serious Tone	
Casual and Conversational Tone	
Humorous Tone	
Commanding and Shouting Tone	

Adapted Parental Mediation of DA Measure

Scales and Items	Response Modality
Active Mediation of DA use *(When your child uses the Digital Assistant at home, do you...)*	Frequency Scale (1: Never– 5: Always)
Talk to your children about what they do with the DA?	
Encourage your children to explore and learn things with the DA?	
Sit with your children while they use the DA?	
Stay nearby when your children uses the DA?	
Do shared activities together with your children and the DA?	
Child-Initiated Support *(Has your child ever...)*	Binary Scale (0: No – 1: Yes)
Initiated a discussion with you about what they do with the DA?	
Told you about something they heard from the DA that they found disturbing?	
Asked for your advice on how they should act with the DA?	
Asked for products and/or services that they have heard advertisements for, on the DA?	
Asked for your help when the DA did not understand their request?	
Asked for your help concerning a situation with the DA that they cannot handle?	
Active mediation of DA Safety *(How often do you do any of these things with your child?)*	Frequency Scale (1: Never– 5: Always)
Help them when something is difficult to do or to find with the DA	
Suggest ways to use the DA safely	
Explain why some DA commands/searches are appropriate or inappropriate	
Help them when something has bothered them with the DA	
Talk to them about what to do if something about the DA bothered them	
Explain that DA games may contain hidden advertising aimed at making children want to have new products	
Explain that DA games, even if downloaded without cost, may require in-app purchases in order to progress faster in the game or to access the full features of the game	
Talk to them about the commercial activities they are exposed to with the DA	
Technical Controls *(Do you (or your partner/other carer) make use of any of the following…)*	Binary Scale (0: No – 1: Yes)
Parental controls or other means of blocking or filtering types of content/DA commands	

Rules about how long or when your children are allowed to use your DA	
A service or contract that limits the time your children spends with your DA	
Parental controls that filter the apps/skills your children can download	
Parental controls that alert you when your children wants to buy content (in-app purchase)	
Parental Monitoring *(When your child uses the DA, how often do you (or your partner/other carer) check the following things afterwards?)*	Frequency Scale (1: Never– 5: Always)
DA commands your children have used	
Search History on the DA	
The apps/skills your children downloaded	
The in-app purchases your children made	
Parental Restrictions *(For each of these DA uses, do you let your child whenever they want, only with your permission, never allow them to use this function or are your children not interested in this function?)*	Restriction Scale (0:Can do this anytime, 1:with permission, 2:never)
Knowledge Search	
Media & Entertainment	
Weather	
Clock & Time	
Games & Jokes	
Productivity	
Smart Home	
Communication	
Education & Learning	
News	
Shopping & Delivery	
Fitness & Wellness	
Finance	

Note. Parental Mediation of DA use adapted from Livingstone et al. (2017) parental mediation of internet use measure

Appendix E
Study 2 Participant Recruitment using Prolific

“Ok Google, how tall is the sky” How parents and children use digital assistants (i.e. smart speakers) at home

We are recruiting parents of children between 4-8 years of age who have a digital assistant in their homes to participate in a research study by Technology, Learning and Cognition Lab at McGill University in Canada. Our study aims to understand how parents and children use digital assistants in the home, how parents regulate/guide their child’s use of digital assistants, and how children relate ot intelligent technologies. The survey should take 30 minutes to complete

Devices that can participate in study: Mobile, Tablet and Desktop

Study Link: (Link to Study hosted on Qualtrics)

Recruit Participants: 300

Location: 100 participants each from USA, UK and Canada

Payment provided: $CAD 10

Appendix F
Study 2 Participant Consent Form

McGill

Department of
Educational and Counselling Psychology
in the Faculty of Education

Département de
psychopédagogie et de counseling
de la Faculté des sciences de l'éducation

Title of Study: "Ok Google, how tall is the sky?" How parents and children use digital assistants (i.e., smart speakers) at home.

Principal Investigator: Professor Adam K. Dubé
adam.dube@mcgill.ca
Assistant Professor, Learning Sciences Program
Department of Educational & Counselling Psychology
McGill University

Sponsors: Social Science and Humanities Research Council

Research Team: Adam Dubé, PhD; Victoria Talwar, PhD; Elizabeth Patitsas, PhD; Nandini Asavari Bharadwaj (Research Assistant)

Purpose of the Study: Embedding computers and the internet in everyday objects has resulted in connected and interactive homes. Parents can lock their doors, dim the lights, ask if the fridge is out of milk and order more, all with their voice during family dinner. While this may seem futuristic, 46% of adults use digital assistants and Amazon reports selling over 100 million Alexa digital assistants across thousands of form factors. The connected home environment of today's child begs the question of how the use of digital assistants will shape children's beliefs of how intelligent technologies function (i.e., theory of artificial minds) and influence how children evaluate information learned from these knowledge objects (i.e., Pennycook & Rand, 2018).

The proposed research will detail how parents and children use intelligent technologies in the home with the long-term goal of identify whether parents and children's use of digital assistants to conduct everyday knowledge search (e.g., 'Alexa, who is the president of the USA?') affects children's ability to identify false information learned online.

Participants: You are being asked to participate in the study because you have a digital assistant in your home and you are a parent of a child 4-8 years of age.

Procedures: If you agree to participate in this study, you will complete an online survey about the use of digital assistants in your home as well as some demographic questions (age, # of children). The questions include: what type(s) of digital assistant(s) are in your home; how do you and your child use your digital assistant in your home; what type of questions do you and your child ask your digital assistant in your home (e.g., child asking "Ok Google, how tall is the sky?); and questions on how you regulate/guide your child's use of digital assistants (e.g., do you stay near them when the use digital assistants).

The study will take approximately 30 minutes to complete and does not require any follow-up participation. *This study has been reviewed and approved for ethical compliance by the McGill University Research Ethics Board.* General results will be made available to you on request.

Benefits of Participation: Possible benefits from study participation include an opportunity to reflect on how you and your children use digital assistants in your home.

Risks of Participation: There are no risks associated with participating in this study.

Cost /Compensation: Participants will receive appropriate compensation for their participation.

Contact Information/Questions: If you have any questions or concerns about the study, you may contact the Principal Investigator, Professor Adam K. Dubé (teklrncog@gmail.com).

If you have any ethical concerns or complaints about your participation in this study and want to speak with someone not on the research team, please contact the McGill Ethics Manager (lynda.mcneil@mcgill.ca; 514-398-6831) referencing REB #19-12-010.

Voluntary Participation: Your participation in this study is voluntary. You may refuse to participate in this study, and you may withdraw from the study at any time. You are encouraged to ask questions about this study at any time prior to or after the study via email. If you choose to withdraw during the study, all information obtained up until that point will be destroyed. If you choose to withdraw after completing the study, email us within one month of your participation and provide your Prolific ID.

Confidentiality: Your participation and answers will be confidential; only your Prolific ID will be associated with your responses and this ID will be disassociated from the responses 1 month after data collection is completed. All digital records of the disassociated responses will be saved in password encrypted files in a locked facility at McGill University for at least 7 years following study completion at which time it will be destroyed. Access to participants' data will be limited to members of the research laboratory of Professor Adam K. Dubé and the research team listed above.

Please click 'I CONSENT' below if you have read the above information and consent to participate in this study. Agreeing to participate in this study does not waive any of your rights or release the researchers from their responsibilities. To obtain a copy of this form, please print or save this page for your records.

Appendix G
Study 2 Survey Questions

1. Please read the consent form and confirm the following:

   I confirm that I am a parent of a child 4-8 years of age
   I confirm I confirm that I own a digital assistant (E.g. Amazon Alexa, Google Home, Apple Siri, etc.)
   I confirm that I have not taken any form of this survey before

2. What is your Prolific ID? (Textbox)
3. What is your age in years? (Choose from dropdown options)
4. How would you describe yourself? (Check all that apply)

   White
   Black or African American
   Indigenous
   Arab
   Latin American
   South Asian (e.g., East Indian, Pakistani, Sri Lankan)
   Southeast Asian (e.g., Vietnamese, Cambodian, Laotian, Thai)
   West Asian (e.g., Iranian, Afghan)
   Chinese
   Filipino
   Korean
   Japanese
   Other

5. What is your Gender?

   Female
   Male
   Other (Please specify)

6. What is your nationality? (Choose from dropdown options)
7. What country do you currently live in? (Choose one)

   United States of America
   Canada
   United Kingdom

8. Which of the following best describes where you currently live? (Choose one)

   Major Urban Centre
   Medium-sized or Small Town

Rural or Pastoral Area

9. What is the highest level of school you have completed or the highest degree you have received? (Choose one)

    Primary School
    High school degree or equivalent (e.g., GED)
    CEGEP or college degree
    Bachelor/ Trade/ Technical degree
    Graduate degree
    Other (please specify)

10. What is your yearly household income in your currency? (Choose one that applies)

    Less than $20,000
    $20,000 to $34,999
    $35,000 to $49,999
    $50,000 to $74,999
    $75,000 to $99,999
    $100,000 to $149,999
    $150,000 to $199,999
    $200,000 or more

11. How many children (ages 4-8 years) do you have? (Choose from dropdown options 1-5)

12. Please indicate the ages and gender of your children

    Age of Child 1 | Gender of Child 1
    Age of Child 2 | Gender of Child 2
    Age of Child 3 | Gender of Child 3
    Age of Child 4 | Gender of Child 4
    Age of Child5 | Gender of Child 5

13. What type of digital assistant/smart speaker do you use at home? (Check all that apply)

    Google Assistant
    Amazon Alexa
    Apple Siri
    Samsung Bixby
    Microsoft Cortana

14. How long have you owned your digital assistant/smart speaker? (Choose one)

    Less than 6 months
    6 months to 1 year
    1 year to 2 years

More than 2 years

15. What type of digital assistant do you own? (Check all that apply)
    Smart Speaker
    Smart speaker with screen
    Smart Clock

16. In a typical week, how often do you use your digital assistant for the following purposes? (Radio Buttons)

Category	Never	Rarely (A few times a week)	Sometimes (Once every few days)	Often (Daily 1-2 exchanges)	Frequently (Daily; multiple exchanges)
Knowledge Search *Search and lookup different kinds of knowledge and information*					
Media & Entertainment *Play different kinds of media and entertainment such as music, videos, podcasts, audiobooks*					
Weather *Look up weather conditions in past, present and future*					
Clock & Time *Look up date and time, set a timer or alarm, use stopwatch*					
Games & Jokes *Play fun activities such as games, jokes, humorous noises*					
Productivity *Manage tasks and organize life with calendar, map directions, shopping lists, reminders, emails*					
Smart Home *Control and/or find smart devices in house such as security devices, lights, thermostat, plugs, cameras, vacuums, and other connected devices*					
Communication *Make phone or video calls and use as intercom*					
Education & Learning *Play education and learning content such as word of the day, this day in history, spelling and vocabulary activities, Wikipedia searches*					
News *Hear daily news, news briefings, flash news briefing and related updates*					
Shopping & Delivery *Conduct ecommerce transactions, online shopping activities, food delivery, order a taxi*					
Fitness & Wellness *Start a fitness routine, timed workout and guided meditation*					
Finance *Conduct financial transactions and lookup personal financial information*					

17. In a typical week, how often do your children use your digital assistant for the following purposes? (Radio Buttons)

Category	Never	Rarely (A few times a week)	Sometimes (Once every few days)	Often (Daily 1-2 exchanges)	Frequently (Daily; multiple exchanges)
Knowledge Search *Search and lookup different kinds of knowledge and information*					
Media & Entertainment *Play different kinds of media and entertainment such as music, videos, podcasts, audiobooks*					
Weather *Look up weather conditions in past, present and future*					
Clock & Time *Look up date and time, set a timer or alarm, use stopwatch*					
Games & Jokes *Play fun activities such as games, jokes, humorous noises*					
Productivity *Manage tasks and organize life with calendar, map directions, shopping lists, reminders, emails*					
Smart Home *Control and/or find smart devices in house such as security devices, lights, thermostat, plugs, cameras, vacuums, and other connected devices*					
Communication *Make phone or video calls and use as intercom*					
Education & Learning *Play education and learning content such as word of the day, this day in history, spelling and vocabulary activities, Wikipedia searches*					
News *Hear daily news, news briefings, flash news briefing and related updates*					
Shopping & Delivery *Conduct ecommerce transactions, online shopping activities, food delivery, order a taxi*					
Fitness & Wellness *Start a fitness routine, timed workout and guided meditation*					
Finance *Conduct financial transactions and lookup personal financial information*					

18. *In case respondents choose options other than "Never" as response above,* Do you let your children use the DA for "Purpose" (e.g. Weather, News) whenever they want or only with your permission or supervision?

    My children can use the DA for this function whenever they want
    My children can only do this with my permission or supervision.

19. *In case respondents choose option "Never" as response above,* Why do your children not use the DA for "Purpose" (e.g. Weather, News)?

    My children are not interested in this function
    I do not allow my children to use this function on the DA

20. In a typical week, how often do you use your digital assistant to search for the following knowledge-based topics?

Category	Never	Rarely (A few times a week)	Sometimes (Once every few days)	Often (Daily 1-2 exchanges)	Frequently (Daily; multiple exchanges)
General Knowledge *General information about the world*					
Language *Word meanings, definitions, spellings, translations*					
Media, Arts and Culture *Celebrities, TV and films, Arts and media*					
Nature *Natural world, animals, plants*					
Science and Technology *Science news, scientific explanations, technology updates*					
Digital Assistant *Digital assistant personality, Digital assistant thoughts, Digital assistant behaviors, Digital assistant features*					
Food and Cooking *Recipes, cooking times, cuisine information*					
Public Holidays & Festivals *Holiday dates, holiday significance, holiday history*					
Maps & Geography *World geography, Map information, Place and Distance information*					
Product Reviews *Technology reviews, product reviews*					
Video Games and Board Games *Video games, board games, gameplay information, game tutorials, release dates*					
Home & household activities *Home activities, household schedules and routines*					
How-to *How to perform a particular task, guidance on tasks*					
Math *Calculations, quick math problems, math guidance*					
Sports & Sporting Events *Sporting games scores, Sport news, sports information*					
Finance *Economy information, Stock market information, stock prices*					
Unit Conversions *Converting units across measurement systems*					

21. In a typical week, how often do you use your digital assistant to search for the following knowledge-based topics?

Category	Never	Rarely (A few times a week)	Sometimes (Once every few days)	Often (Daily 1-2 exchanges)	Frequently (Daily; multiple exchanges)
General Knowledge *General information about the world*					
Language *Word meanings, definitions, spellings, translations*					
Media, Arts and Culture *Celebrities, TV and films, Arts and media*					
Nature *Natural world, animals, plants*					
Science and Technology *Science news, scientific explanations, technology updates*					
Digital Assistant *Digital assistant personality, Digital assistant thoughts, Digital assistant behaviors, Digital assistant features*					
Food and Cooking *Recipes, cooking times, cuisine information*					
Public Holidays & Festivals *Holiday dates, holiday significance, holiday history*					
Maps & Geography *World geography, Map information, Place and Distance information*					
Product Reviews *Technology reviews, product reviews*					
Video Games and Board Games *Video games, board games, gameplay information, game tutorials, release dates*					
Home & household activities *Home activities, household schedules and routines*					
How-to *How to perform a particular task, guidance on tasks*					
Math *Calculations, quick math problems, math guidance*					
Sports & Sporting Events *Sporting games scores, Sport news, sports information*					
Finance *Economy information, Stock market information, stock prices*					
Unit Conversions *Converting units across measurement systems*					

22. How often do your child(ren) ages 4-8 years like to independently interact with your DA?

    Never
    Rarely (1-2 times a week)
    Sometimes (3+ times a week)
    Often (1-2 times a day)
    Frequently (3+ times a day)

23. How comfortable are your child(ren) ages 4-8 years, with using your DA?

    Extremely uncomfortable
    Somewhat uncomfortable
    Neither comfortable nor uncomfortable
    Somewhat comfortable
    Extremely comfortable

24. When your child(ren) ages 4-8 years use the DA at home, do you…

	Never	**Rarely**	**Sometimes**	**Often**	**Frequently**
Talk to your children about what they do with the DA?					
Encourage your children to explore and learn things with the DA?					
Sit with your children while they use the DA?					
Stay nearby when your children uses the DA?					
Do shared activities together with your children and the DA?					

25. Have your child(ren) ages 4-8 years ever…

	Yes	**No**
Initiated a discussion with you about what they do with the DA?		
Told you about something they heard from the DA that they found disturbing?		
Asked for your advice on how they should act with the DA?		
Asked for products and/or services that they have heard advertisements for, on the DA?		
Asked for your help when the DA did not understand their request?		
Ask for your help concerning a situation with the DA that they cannot handle?		

26. How often do you do any of these things with your child(ren) age 4-8 years?

	Never	**Rarely**	**Sometimes**	**Often**	**Frequently**
Help them when something is difficult to do or to find with the DA					
Suggest ways to use the DA safely					
Explain why some DA commands/searches are appropriate or inappropriate					
Help them when something has bothered them with the DA					
Talk to them about what to do if something about the DA bothered them					
Explain that DA games may contain hidden advertising aimed at making children want to have new products					
Explain that DA games, even if downloaded without cost, may require in-app purchases in order to progress faster in the game or to access the full features of the game					
Talk to them about the commercial activities they are exposed to with the DA					

27. Do you (or your partner/other carer) make use of any of the following…

	Yes	**No**
Parental controls or other means of blocking or filtering some types of content/DA commands		
Rules about how long or when your children are allowed to use your DA		
A service or contract that limits the time your children spends with your DA		
Parental controls that filter the apps/skills your children can download		
Parental controls that alert you when your children wants to buy content (in-app purchase)		

28. When your child(ren) ages 4-8 years use the digital assistant, how often do you (or your partner/other carer) check the following things afterwards?

	Never	**Rarely**	**Sometimes**	**Often**	**Frequently**
DA commands your children have used					
Search History on the DA					
The apps/skills your children downloaded					
The in-app purchases your children made					

29. How reliable do you think your digital assistant is as an information source? (Choose one)

    Extremely reliable
    Reliable
    Neither reliable nor unreliable
    Unreliable
    Extremely unreliable

30. According to your child(ren) ages 4-8 years, how reliable is your digital assistant is as an information source? (Choose one)

    Extremely reliable
    Reliable
    Neither reliable nor unreliable
    Unreliable
    Extremely unreliable

31. To what extent would you agree with the following statements, about the relationship your child(ren) age 4-8 years, share with your digital assistant (DA)?

	Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Strongly agree**
My children, interact with the DA as if it were a human					
My children interact with the DA as if it were a machine					
My children only interact with the DA as and when they need something					
My children have a friendly relationship with the DA, as if it were a friend					
My children like to be primarily entertained by the DA					
My children like to learn information from the DA, as if it was a teacher					
My children share no relationship with the DA					

32. To what extent would you agree with the following statements, about the tone your child(ren) age 4-8 years use, when using your digital assistant?

	Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Strongly agree**
My children mostly mimic my tone of speaking					
My children adopt a formal and serious tone					
My children adopt a casual and conversational tone					
My children adopt a humorous tone					
My children adopt a commanding and shouting tone					

33. Would your child(ren) age 4-8 years, describe your digital assistant using the following adjectives?

	Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Strongly agree**
Smart					
Trustworthy					
Alive					
Safe					
Funny					