Children prefer to learn from smart devices, but do not trust them more than humans

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Abstract

Despite the rise in prevalence of voice-activated smart devices and their potential to influence how young children learn about the world, we know little about how children interact with and learn from these devices. In the current study, 5- to 6-year-old children (n=30) were asked whether they wanted to learn more information about a series of obscure animals from an Amazon Echo or a human confederate. After informants gave contradictory answers, participants were asked whose information they trusted. Children significantly preferred to request information from the Amazon Echo but showed no preference with regards to whose information they endorsed. Furthermore, performance was not affected by technology experience. While children enjoy interacting with smart devices, they may not believe the information that they receive.

Keywords: smart devices, mobile technology, trust, speaker reliability

1. Introduction

Children today are growing up in a society in which they are surrounded by digital technology. A recent survey of 1400 parents in the United States with children aged eight and under reported that 98% of families live in a home with some form of mobile device. Moreover, time spent interacting with mobile devices has tripled from five minutes per day in 2011 to 48 minutes per day in 2017 [1]. During the COVID-19 pandemic, over half of children aged 6 to 12 years reported a 50% increase in screen time use [2].

Smart, interactive speakers such as Google Home and Amazon Echo in particular have increased their prevalence in recent years. Statistics show that such devices are outpacing the adoption rates of smartphones and tablets; one in five Americans currently owns a voice-activated smart speaker [3]. Compared to the traditional screen-based devices, smart speakers are easier to navigate because they only require voice activation and provide instantaneous answers. This user friendly system may be beneficial to young children, who may not know how to search for answers to their questions, potentially playing an earlier and more influential role in children's lives. While there is no data on how the pandemic has affected children's smart device usage, the increase in screen time suggests that children's smart device usage has probably also increased as well.

The ease of operating interactive devices encourages people to use this technology to learn new information. It was reported that 74% of people use interactive devices to answer general questions [3]. A recent study revealed that young children, especially those who were not old enough to read or type to look up the answers on the Internet, used smart speakers for simple knowledge queries (the paper does not give examples of such queries) [4]. Several studies also identified the notion that children often had to reformulate questions to get correct responses

from smart assistants ([5], [6], [7]). While some adults are happy about children's use of smart speakers to gain knowledge, others are concerned about children's privacy when near smart speakers that were continuously "on" [8], their ability to control devices without adult intervention, and their attachment to smart assistants [9]. Due to the increasing prevalence of smart devices and the fact that children seek information from them, as well as parental concern about smart device use, we need to understand how children interact with these devices and how they process the information that they receive from them.

The CommonSense media study on children's interactions with smart speakers revealed that most children associate smart speakers with robots [10]. While many experiments have tested how children interact with robots [11], empirical data on how children interact with smart devices like the Amazon Echo or Google Home is limited. Much existing research focuses on usability or privacy from the parents' point of view or use qualitative measures ([4], [8] , [12]). There are no controlled laboratory studies, to the authors knowledge, that examine how children interact with and interpret information gained from smart devices.

There have been controlled studies, however, that focus on understanding children's behavior when searching for information on the Internet. Elementary school children need assistance with spelling, typing and vocabulary to improve search results [13]. Spink et al. provide several insights into how 5- and 6-year-old children create search queries and navigate the results [14], while Bilal describes the strategies used by seven year old children when using the search engine called Yahooligans that was developed for children ages 7 to 12 ([15], [16]). Smart assistants make it easier for young children to find information, without having to know the correct spelling of keywords or having to type the query using a keyboard or a touchscreen.

These devices also provide them with the most relevant answer, thus taking away the burden of navigating many of a search engine's results on their own.

Previous research from the field of developmental psychology on how children interact with different types of potential informants can help guide questions about learning from smart devices. Specifically, researchers have explored what kinds of informants children want to learn from and trust. By five years of age, children tend to want to learn from and trust informants who are similar to them ([17], [18], [19], [20]). For instance, five-year-old children demonstrate a similarity bias when they request information, such that they systematically seek information from similar informants (operationalized as those with the same hair color and favorite food) over dissimilar informants, even over and above informants' past reliability. They also are more likely to trust (endorse) information from a similar agent ([19], [20]). Pre-linguistic infants also prefer agents who share even trivial similarities with themselves, such as the same food preference, and these preferences appear to reflect a cognitive comparison process ('like me'/'not like me'; [18]). In sum, there is ample evidence that young children use shared attributes to guide their learning decisions and generally prefer to learn from informants who are like them.

Additionally, children have a bias to want to learn from informants who are familiar to them [21]. For example, four-year-old children endorse objective and subjective claims made by a familiar character over those made by an unfamiliar character even when children knew that the familiar character was unreliable [22]. This bias, although demonstrated in interactions with humans or animated agents (such as puppets or cartoon characters), points to some predictions for when children will choose to interact with smart devices. It is possible, for example, that children who are more familiar with certain smart devices will be driven to interact with them more.

Whether similarity biases transfer to smart device interaction is less clear. Devices like the Amazon Echo are not physically similar to children, but it is possible that children attribute an "inner life" to smart devices that could lead to the perception of internal similarities. In fact, while adults attribute perceptual and cognitive abilities, but not social-emotional abilities, to robots, children appear to be more flexible across these domains, and in particular the social-emotional domain. For example, 7- to 9-year old children tend to endorse the statement that robots have a personality and can have hurt feelings [23]. Thus, it is possible that children may attribute an internal preference, desire, or characteristic to a smart device that may drive their desire to interact with it, despite the fact that the device does not physically look like them. However, there is some evidence that the less a robot looks like a human, the less likely children are to attribute emotions to it [24]. Since smart devices are not designed to look animate, it may be difficult for children to see any internal similarities between themselves and the device.

Given the increasing presence of smart devices in homes, in addition to the fact that almost half of parents report that children interact with the Amazon Echo primarily by asking it questions [2], it is important to understand when and why young children choose to seek information from a smart speaker over a human. In the current study, we presented 5- to 6-year-old children with three unfamiliar animals and asked them to choose to learn more about these animals from either a human confederate or the Amazon Echo. By providing contradictory answers from both the Echo and the human, we then probed whose information they trusted more. Lastly, we investigated whether previous experience with the Echo and other similar devices influenced children's behavior. Based on previous studies demonstrating that children prefer to interact with and trust agents that are more similar to them ([19], [20]), we predicted that children would choose to learn from and trust the human confederate over the Echo. Based

on the familiarity bias literature [22], we also predicted that children with more previous experience using smart devices might show a weaker human bias.

2. Material and Methods

2.1. Participants

Based on previous studies on robot learning and trustworthiness ([19], [25]), we tested 5- to 6-year-old children. Participants were recruited from the community around the New York Capital Region (predominately white and middle-class) and compensated with a book or a lab t-shirt. While we planned to exclude participants if they did not make it through the entire experiment, all participants completed all trials. We excluded participants if the Echo did not give the appropriate answer after three attempts for any requesting test trial (n = 1), or if there was parental interference (n = 1). Our pre-registered stopping rule was n = 24 (based on samples sizes from previous studies), or as many participants as we could run before September 1, 2019. Our final sample consisted of n = 30 5- to 6-year-old children. (mean age = 6;1, range = 5;0 to 6;11). Parental consent was obtained for all participants according to the Skidmore College Institutional Review Board.

2.1. Stimuli

An Amazon Echo dot was used for the experiment. Children were introduced to three obscure animals; a tarsier, a thorny dragon, and an okapi. These animals were chosen because (a) they are not commonly known animals for children in North America and (b) the Amazon Echo gave concise and easy to understand responses when asked where the animals were from (see Table 1). For each, a laminated picture of the animal was created.

Table 1
Obscure Animal Stimuli

Animal	Description	Native Region
Tarsier	A lemur-like, small brown fuzzy animal with large eyes and large ears	The Philippines and Asia
Thorny Dragon	A small lizard-like reptile with multiple shades of brown and yellow spikes throughout its body	Australia
Okapi	Known as the forest giraffe, a medium-sized animal that has a giraffe's head, a deer's body, and a zebra's legs	Africa, the Democratic Republic of the Congo, and Central Africa

Note. Obscure animals and their native region (the Echo's responses).

2.2. **Design and Procedure**

Children were brought into a separate testing room with the experimenter, a human confederate, and the Amazon Echo. Each child participated in a *familiarization phase* and a *test phase*, the latter of which consisted of a *requesting trial*, and an *endorsing trial* (procedure adapted from [19]). In the familiarization phase, children were introduced to a human confederate and the Amazon Echo. Then, they were tested to see who they wanted to learn from (*requesting trial*) and whose information they trusted (*endorsing trial*). The request-endorse sequence was repeated three times, once for each obscure animal.

2.3. ***Familiarization phase***

Children were first introduced to the Amazon Echo, referred to as Alexa: "This is my friend Alexa. Do you want to say hi to Alexa?". They were then instructed on how to talk to Alexa: "Whenever you ask Alexa a question, you have to first say her name. Watch me: Alexa, what day is today? [Alexa answers]. Do you want to try asking Alexa a question?" (If the child

did not generate their own question, the experimenter said they could ask her what 4 + 6 was). Then, to balance the time spent talking to each agent, the experimenter introduced the human confederate: "This is my friend Sami. Do you want to say hi to Sami?" [Child said hi] "Do you want to ask Sami a question?" [Child asks a question that human confederate answered]. Then, the experimenter told the child they were going to play a game with Alexa and Sami.

2.4. ***Test phase***

There were three test trials, each consisting of a request-endorse sequence. Children were handed a picture of an obscure animal. The experimenter said the animal's name (e.g., "This is a tarsier*"*) and asked if the participant knew where the animal was from. The experimenter then said, "I don't know where [animal name] are from but one of them [experimenter motioned to the Echo and the human confederate] might know. Who would you like to ask?" If the participant said that they did know where the animal was from, the experimenter would say, "I'm not sure if that's right, but one of them might know. Who would you like to ask?".

After the participant made their choice, the experimenter recorded who the child requested to learn from (the *requesting trial*). The experimenter then asked the appropriate agent, "Where is [animal] from?" Note that while previous studies using this paradigm have had children request the information, due to the fact that the Amazon Echo is unreliable at understanding speech, the experimenter always interacted with the Echo during the test phase to reduce the likelihood of error. After the first agent gave their answer, the experimenter asked the other agent: "Let's see where Sami/Alexa thinks that a [animal] is from." Regardless of who was asked first, the human always provided a different answer than the Echo (see Table 2).

Next, for the *endorsing trial,* the experimenter re-stated the different answers, in the order in which they were given, and asked who the child believed (for example, "Alexa says that

tarsiers are from the Philippines and Asia and Sami says that tarsiers are from Alaska and Antarctica. Where do you think tarsiers are from?"). If the child said they didn't know, the experimenter asked them to give their best guess. The experimenter recorded the child's answers. The *requesting* and *endorsing trials* were repeated two more times with two additional obscure animals for a total of three trials per participant. Trial order was counterbalanced across participants.

Table 2
Responses From Each Agent (Alexa and Sami)

Agent	Animal	Response
Alexa	Tarsier	The Philippines and Asia
Sami		Alaska and Antarctica
Alexa	Thorny Dragon	Australia
Sami		Israel
Alexa	Okapi	Africa, the Democratic Republic of the Congo, and Central Africa
Sami		Japan, China, and Indonesia

Note. Responses to the question, "Let's see where Sami/Alexa thinks that a [animal] is from."

2.5. ***Questionnaires***

To assess technology experience, we developed a questionnaire based on the one provided by Kirkorian and Choi [26]. This questionnaire addressed demographic information (parents' education, child's race and ethnicity; Table A1) and the child's media use (Table A2). Parents filled out the questionnaire while the child was being tested. The main question of interest in the survey asked parents to report how many minutes participants spent on an interactive device the day before. This particular measure has been used in previous research to examine the relationship between technology experience and performance in a lab task [26].

3. Results

Data was analyzed with the lme4 package (version 1.1-18-1) and the lsr package (version 0.5) in R (version 3.5.1) ([27], [28]). The analyses reported below, except for those marked "exploratory", were all pre-registered. The data and analysis scripts, as well as our pre-registration, are on the Open Science Framework (blinded pre-registration: https://osf.io/ntvah/?view_only=13356110a75645f6a7302219bbf656d5; data and analysis scripts: https://osf.io/stjw9/?view_only=0cc0625ca71f443f8948de541117edca). For the technology experience variable (usage of interactive devices the day before in minutes), the mean response was 57.8 minutes (range = 0-180), but there was a positive skew such that the modal response was 0 minutes.

3.1. **Requesting Trials**

Data was analyzed with mixed-effects logistic regression with technology experience as a fixed effect and subject and item as random intercepts. The dependent variable was whether they requested to learn from the human (1) or the Echo (0). First, we compared a base model with only the random effects to a model with technology experience. For this model comparison, we only included 25 participants because five participants did not complete the questionnaire. Adding technology experience did not explain significantly more variance than the base model ($\Delta LL = -43.7$, $p = 0.215$).

In the base model (n=30), children were significantly more likely to request to learn from the Echo compared to the human ($\beta = -0.835$, $SE = 0.265$, $z = -3.151$, $p = 0.002$), and this pattern held across all three trials (see Figures 1 & 2). As a second, corroborating analysis, we also computed a requesting score for each participant representing how often they chose the

human (one point per trial, such that choosing the human every time would result in a score of three, and choosing the Echo every time would result in a score of zero), and ran a two-tailed one-sample t-test comparing that dependent variable to chance (1.5; analysis based on Reyes-Jaquez and Echols, 2013 [19]). Participants were significantly more likely than chance to choose the Echo, $t(29) = -4.331$, $p < 0.001$, Cohen's $d = 0.791$.

In the model including technology experience (n=25), children were still significantly more likely to request to learn from the Echo ($\beta = -1.335$, $SE = 0.422$, $z = -3.160$, $p = 0.002$), and technology experience did not significantly explain request choice, ($\beta = 0.00639$, $SE = 0.00518$, $z = 1.234$, $p = 0.217$). As a second, corroborating analysis, we ran a correlation between children's requesting score and technology experience. The correlation was not significant $r(23) = 0.247$, $p = 0.233$.

3.2. **Endorsing Trials**

The same analysis was done for the endorsing trials. Adding technology experience did not explain significantly more variance than the base model ($\Delta LL = -48.9$, $p = 0.931$). In the base model, children were not significantly more likely to endorse the Echo compared to the human ($\beta = -0.423$, $SE = 0.286$, $z = -1.479$, $p = 0.139$), and the pattern held across all trials (see Figures 1 & 2). As a second corroborating analysis, we also computed an endorsing score for each participant representing how often they endorsed the human (analogous to the requesting score; see description above). Participants were not significantly more likely than chance to endorse the Echo, $t(29) = -1.304$, $p = 0.203$, Cohen's $d = 0.238$.

In the technology model, children were not significantly more likely to endorse the Echo ($\beta = -0.531$, $SE = 0.511$, $z = -1.040$, $p = 0.298$), and technology experience did not significantly explain endorsing choice, ($\beta = -0.00058$, $SE = 0.00662$, $z = -0.087$, $p = 0.931$). As a second

corroborating analysis, we ran a correlation between endorsing score and technology experience. The correlation was not significant r(23) = -0.0156, p=0.941.

We also ran exploratory Pearson's product-moment correlations between the endorsing and requesting scores and all of the scale variables on the technology use questionnaire (see Table A2). After correcting the alpha value for multiple comparisons using the Bonferroni method, none of the correlations were significant.

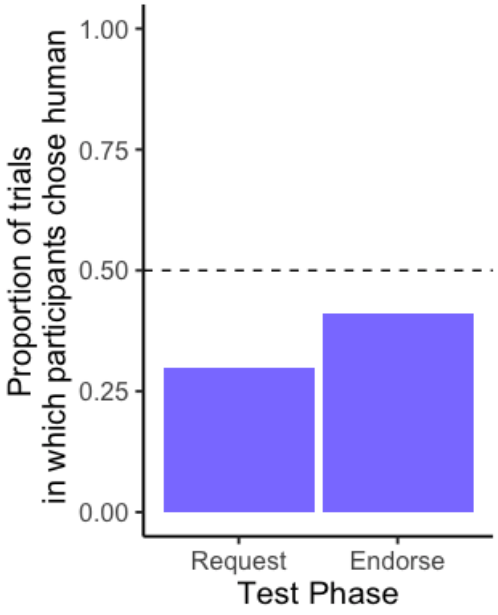

Figure 1. The proportion of trials across all children (n=30) and trials (n=3) in which participants selected the human agent over the Amazon Echo. The dashed line represents chance.

Figure 2. The proportion of trials across all children (n=30) in which participants selected the human agent over the Amazon Echo, separated by trial. The dashed line represents chance.

4. Discussion

We used an information learning paradigm that typically involves two humans (or human-like entities) to test an important and timely question about children's interest in interacting with smart devices and consequently their trust in the information provided. Our study demonstrates that 5- to 6-year-old children prefer to request information from an Amazon Echo over a human, but critically do not show a preference for either type of informant when asked whose information they trusted. Indeed, across all three test trials, the proportion of children who endorsed the answer given by the human was higher than the proportion of children who requested information from the human. We also found that neither preference was influenced by the amount of time children spent with interactive technology the day before or other measures of technology experience. Both of these results conflict with our predictions; due to past literature showing that children prefer to interact with and trust agents who are similar

and familiar to them [19], we predicted that children would choose the human informant over the Amazon Echo on both the requesting and endorsing trial types.

Our findings suggest that while children may enjoy interacting with smart devices (see for example, [29]) and often interact with smart devices by asking information-seeking questions [4], they may not trust the information that they receive. It is thus possible that children are drawn to ask smart devices questions because of the novelty and fun of the interaction, rather than because they believe it will provide the most reliable information. Indeed, a survey found that 12% of children reported that they use smart devices to talk or fool around with [1].

It is also possible, though, that the lack of an Amazon Echo preference in the endorsing (trust) trial was due to social pressure. Given that children are less likely to attribute emotions to robots when they do not look human-like [24], it is possible that the participants felt a social obligation to select the human participant, over the non-feeling Echo, when asked who they believed. Future studies can test this hypothesis by having the human informant participate over a video chat program or a phone call to remove the physical presence of the human.

It is also surprising that we did not find any relationship between past technology experience and either of our in-lab measures, or any suggestion of a relationship between our other survey questions about technology familiarity and use and our in-lab measures. These null results suggest that the attraction to interact with the Amazon Echo is independent of familiarity. This finding is supported by past research that found that smart devices are engaging even for children who do not have technology experience [29]. However, it contradicts past work with interactive tablets, which found that previous interactive device usage correlates with performance on a tablet-based memory task [26]. Note that this past study found a correlation with past usage and task accuracy, whereas in the present study we examined social preference.

Social interaction behaviors may be uniquely unaffected by past experience with smart devices. Indeed, it is possible that previous smart device usage does affect other aspects of smart device interaction, such as the type of questions that children generate on their own, their ability to flexibly change their speech when the device does not understand a query, or their memory for responses provided by the device.

Further research should continue to explore relationships between device usage and interaction style in children. These relationships are particularly important considering smart devices may be incorporated into educational settings in the near future, and the current rise in children's technology use due to the COVID-19 pandemic. Since smart devices are costly, any effect of past use on how children interact with smart devices should be considered in light of the socio-economic variability within homes, classrooms and across educational institutions. Furthermore, future studies should take demographic information into account when recruiting participants for the sample in order to produce results that can be generalized to a more diverse population.

There are still questions remaining about why children prefer to learn from smart devices over humans, but do not show an analogous trust preference. However, the current study is the first to provide experimental evidence that children's preference to interact with smart devices over humans does not stem from a belief that the information that they receive will be more trustworthy. The increase in prevalence of smart devices in households, combined with our results, suggests that more research is needed to understand how technology today is shaping cognitive development.

Insights for the Human-Computer Interaction community. We hope our research will encourage more collaborative and experimental work focused on children's interactions with

smart devices. It is evident from studies, including ours, that young children enjoy engaging with smart speakers; however, our study uniquely shows that this engagement is not necessarily because they believe that smart devices will give them accurate, trustworthy information. Thus, children may be using smart devices as entertainment, but may not be using them as a learning tool. Future research should explore how we can leverage young children's engagement with and enthusiasm around smart speakers to develop evidence-based applications that are not only fun for children, but also educational. For example, researchers may want to investigate how they can design the format of answers given by smart devices to better convey that the content is trustworthy.

We highlight the lack of controlled, laboratory studies to investigate how children interact with smart devices; such studies are crucial for our understanding of how children interact with and learn from not only smart devices, but all types of social agents. The variables that affect how children learn and remember information can be subtle, and thus well-powered, well-designed studies, which are often necessary to uncover significant effects. Additionally, theories from developmental psychology, such as the social preference work that motivated the present study, may help generate appropriate hypotheses. Thus, we encourage the human computer interaction community to continue to collaborate with developmental/cognitive psychologists to further advance the field of child-computer interaction.

Researching how to make smart devices into effective teachers is particularly important now, in the COVID-19 era. Families and learning communities are relying on technology to not only connect with one another, but also to assist with remote classwork and homeschooling activities. We emphasize the need for more controlled studies on what children can and cannot

learn from smart speakers to lead to the development of applications that can better contribute to early learning and education.

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Appendix

Media Use Questionnaire

Table A1.

Demographic Information

Question	Answer Format
What is your age?	In years
How many years of education have you completed?	12 if completed high school; 14 if completed an Associate's degree; 16 if completed a Bachelor's degree and so on
What are the ages (in years) of all of your children currently residing in your home, including the child(ren) participating in this project?	Child 1: ___, Child 2: ___
In what month and year was your child born?	MM/YY
What is your child's gender?	M/F
Which of the following devices do you have at home?	iPad touch, iPad, touch screen phone, Amazon Echo/Echo dot, Google Home/Google Home mini, Apple TV, Fire TV
How many hours did you spend using those devices yesterday?	In hours

Table A2.

Child's Media Use

Question	Answer format
What day of the week was yesterday?	Day of the week
Do you allow your child to use any interactive devices, such as the following: iPod touch, iPad, touch screen phone, Amazon Echo/Echo dot, Google Home/Google home mini, Apple TV, Fire TV?	Yes or No; If No is selected, then skip to the last question.
At approximately what age did your child first use an interactive device?	In months

At approximately what age did your child first start talking to a voice-activated device (i.e. a smart assistant like Siri or Alexa)	In months
How often does your child use iPod touch?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use iPad?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use touch screen cell phones (e.g. iPhone, Android, Galaxy, Torch)?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use Amazon Echo/Echo dot?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use Google Home/ Google Home mini?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use Apple TV or Fire TV?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use other interactive devices?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the iPod touch?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the iPad?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the touch screen cell phones (e.g. iPhone, Android, Galaxy, Torch)?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the Amazon Echo/Echo dot?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the Google Home/Google Home mini?	Scale from 1 (never or less than once per month) to 5 (daily)
How often does your child use the voice-activation/smart assistant feature of the Apple TV or Fire TV?	Scale from 1 (never or less than once per month) to 5 (daily)

How often does your child use the voice-activation/smart assistant feature of other interactive devices?	Scale from 1 (never or less than once per month) to 5 (daily)
How long did your child use iPod Touch yesterday?	In minutes
How long did your child use iPad yesterday?	In minutes
How long did your child use touch screen cell phones (e.g. iPhone, Android, Galaxy, Torch) yesterday?	In minutes
How long did your child use Amazon Echo/Echo dot yesterday?	In minutes
How long did your child use Google Home/Google Home mini yesterday?	In minutes
How long did your child use Apple TV or Fire TV yesterday?	In minutes
How long did your child use other interactive devices yesterday?	In minutes
How long did your child talk to the iPad yesterday?	In minutes
How long did your child talk to the iPod Touch yesterday?	In minutes
How long did your child talk to the iPad yesterday? (in minutes)	In minutes
How long did your child talk to the touch screen cell phone (e.g. iPhone, Android, Galaxy, Torch) yesterday?	In minutes
How long did your child talk to the Amazon Echo/Echo dot yesterday?	In minutes
How long did your child talk to the Google Home/Google Home mini yesterday?	In minutes
How long did your child talk to the Apple TV or Fire TV yesterday?	In minutes
How long did your child talk to other interactive devices yesterday?	In minutes

Did your child use these types of devices more or less than usual yesterday?	Scale from 1 (About the same) to 3 (Less than usual)
Does your child have their own interactive device? If so, what kind of device or devices?	Yes/No
What rules do you have, if any, for your child's use of interactive devices (both smartphones/tablets in general and voice-activated smart assistants in particular)?	Long response
Please share any final thoughts about touch screen use or other media use by your child.	Long response