Title
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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 44(44)

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Publication Date
2022

Peer reviewed

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Abstract

Children increasingly rely on the internet for information. In this study, children ages 7-10 (n=80) indicated whether a human source or Google could answer questions involving past, present, or future events, and which informant would be better able to do so. Children indicated that Google could accurately answer questions more frequently than the human could, and they were least likely to indicate that either informant could answer questions about the future. Children selected Google as the better informant across all question types, but they did so most frequently in the future condition. Children's responses also varied such that as the age of the participants increased, they judged the person as less able to answer questions about current events and Google as better able to do so. Children believe that search engines can accurately answer questions more often than a person can, perhaps reflecting their exposure to digital learning environments.

Keywords: children; cognitive development; internet; technology; Google; capacity; time

Introduction

From asking a friend for help on a homework problem to going online to find a cheat code for a favorite video game, children seek out information from many different kinds of sources. The internet now allows children to access more information at faster speeds than ever before in human history. Children are taking advantage of this access: according to their parents, most American children ages 0-8 use the internet to watch educational videos, stay connected with family and friends, and do their homework (Rideout & Robb, 2020). However, despite their frequent internet use, children may have difficulty discerning when the internet is an appropriate information source. The current study examines children's evaluations of a human and internet search engine's capacity to provide accurate information about the past, the present, and the future.

Children's Information Seeking

Children are prolific question-askers, and they utilize questions to understand unfamiliar phenomena they experience in the world around them or to add detail to existing ideas and concepts (Coughlin et al., 2014; Frazier et al., 2009; Ronfard et al., 2018; Wellman et al., 2019). They also prefer to ask questions of accurate, reliable, and familiar sources (Harris et al., 2017; Mills et al., 2017). Children as young as age 4 assign questions to informants based on their expertise (Aguiar et al., 2014; Lutz & Keil, 2002) and, by age 6, children are sensitive to what kinds of questions should be directed to others and what kinds of questions they can answer on their own (Fitneva et al., 2013). Thus, children consider multiple factors when making decisions about information sources.

In addition to considering a potential informant's epistemic characteristics, children are sensitive to the kinds of answers sources provide. In response to their questions, children expect to receive answers that are explanatory and non-circular, and they revise their questions if an answer is unclear (Frazier et al., 2009; Mills et al., 2017). However, existing research on children's question-asking patterns deals largely with questions about stable facts, where the answer is finite and relatively permanent, such as questions about object labels (Corriveau & Harris, 2009; Fusaro et al., 2011). Less is known about to whom or what children direct questions about events that are presently occurring or that will occur in the future. Although by age 6, children are capable of thinking about the future and understand that future events have not yet occurred (Zhang & Hudson, 2011), they may find it particularly challenging to identify information sources about future events. Moreover, children now have to navigate between many different kinds of sources, including internet-based devices that have greater computational capacity and access to a broader set of information than any person.

Children's Internet Use

Ninety-eight percent of American children from birth to age 8 live in a home with internet access (Rideout, 2017) and many children are exposed to internet-based devices like cell phones beginning in infancy (Harrison & McTavish, 2018). The majority of American parents believe that understanding how to use the internet from a young age is beneficial for their children (Vittrup et al., 2016), and they report engaging in co-viewing and navigating the internet together with their young children (Rideout & Robb, 2020).

American children as young as age 4 report that they use internet-based devices, like smart phones or tablets, to play games and watch videos (Eisen & Lillard, 2017). However, they do not necessarily see these devices as information

In J. Culbertson, A. Perfors, H. Rabagliati & V. Ramenzoni (Eds.), *Proceedings of the 44th Annual Conference of the Cognitive Science Society.*

sources. In fact, not until around age 7 do American children begin to prefer information derived from the internet or an internet-based source over information derived from a human informant for general knowledge information (Danovitch et al., 2015; Girouard-Hallam & Danovitch, 2022). This is also the age at which they begin to recognize that internet-based devices may not be the best informant, and that a person can more readily know personal information about another person than a device can (Girouard-Hallam & Danovitch, 2022). However, children may still struggle to find information successfully using internet search engines, sometimes failing to formulate an intelligible search query at all (Dodge et al., 2011). They may also ask internet-based devices like voice-assistants to search for information not readily available on the internet (e.g., information about themselves; Yarosh et al., 2018), or look for information in the wrong place (Druin et al., 2010). Additionally, although they show decreased trust in an internet source when it is explicitly inaccurate (Wang et al., in press), children as old as 10 can have difficulty independently identifying misinformation online (Einav et al., 2020). Thus, children may struggle to understand when the internet can provide accurate answers to questions and when it cannot.

Children's difficulty evaluating the internet as an information source may stem from the fact that they do not understand the basic structure of the internet as a network of networks, with malleable interfaces or websites, until at least age 11-12 (Yan 2005, 2006, 2009). Additionally, children and adults typically describe the internet in terms of familiar physical devices (e.g., smartphones or computers) that use the internet (Brodsky et al., 2021). Given how frequently adults use Google (Purcell et al., 2012), children are likely to be familiar with it as a means of obtaining information. By measuring children's judgments about Google's ability to answer different kinds of questions and asking them why they think Google can or cannot answer certain questions, the current study provides insight into how 7-10 year old children understand the informational capacities of the internet.

Current Study

The current study examines children's judgments about the capacity of an internet source (i.e., the Google search engine) to answer questions about past, present, and future events. We investigated children's intuitions about Google's ability to answer questions relative to a person because these intuitions have an impact on children's information gathering in an increasingly digitized era. The majority of American children engaged in online learning in 2020 (McElrath, 2021) and 94% of middle school students cite the internet as a tool for completing school projects (Auxier & Anderson, 2020). Furthermore, although children ages 7 to 9 experience difficulties related to spelling and question formation when performing Google searches (Druin et al., 2010), they prefer the internet over a teacher or peer for questions about historical or scientific facts (Wang et al., 2019). Children's trust in the accuracy of the information obtained from the internet is by no means universal (Danovitch et al., 2015; Wang et al., 2019) and, in some cases, it may even be misguided (Einav et al., 2020; Guerrero et al., 2020). Thus, understanding when and why children turn to Google for information can elucidate how children treat technological informants that are increasingly accessible, but also inherently different from traditional human sources.

The current study explores children's intuitions about human and technological informants in conjunction with the timeliness of the information being sought. Children understand that some information is time-dependent, and some information is stable across time. In a study of 4 to 8-year-old children, children age 6 and older preferred to consult a technological source (in this case, an iPad connected to the internet) over a book for information about time-dependent events like the weather (Eisen & Lillard, 2016). However, they did not show this preference when seeking popular culture information that was stable across time (e.g., the score of yesterday's football game). These results suggest that by age 7 children may think that an internet search engine (i.e., Google) is more capable than a person of providing information about events that are happening today and potentially changing from moment to moment. In contrast, they may believe that both a person and Google can answer questions about events that happened yesterday, if they view those events as general knowledge. For questions about events occurring in the near future (i.e., tomorrow), however, children may struggle to judge whether Google or a human could provide an accurate answer.

To gain a better understanding of the basis for children's judgments, children were prompted to explain why one source would be better than the other at answering each question. We predicted that, when children selected Google, they would focus on Google's ability to store information across time. In contrast, when children selected the person as the better source, we predicted that their explanations would focus on the person's physical and/or perceptual capacity to directly experience the events in question (e.g., the ability to go to the beach) or to gain expertise on the event's subject (e.g., to be a member of the team playing in the game). Children value an informant's perceptual access (Nurmsoo & Robinson, 2009), and may therefore doubt Google's capacity to obtain certain types of information since it cannot directly experience an event.

Our study included participants ages 7 to 10. By age 6, children have a nuanced understanding of mental timelines and can place multiple events sequentially when evaluating events from the past, present, and future, particularly when those events occur closer in time (e.g., yesterday, today, and tomorrow) rather than further apart (e.g., last week or last month; Hudson & Mayhew, 2011; Zhang & Hudson, 2011). They also have a clear understanding of the difference between technological artifacts and living kinds (Jipson & Gelman, 2007), so they should be capable of differentiating between the two sources in this study. Children ages 7 and higher are familiar with the internet, and they are likely to have interacted with the internet at home (Rideout & Robb, 2020). That said, to ensure their familiarity with Google, we

also asked children about their experience using Google to obtain information.

Method

Participants

Participants were 80 children (39 girls, 41 boys) ages 7 to 10 (M = 8.96, SD = 1.47). Three additional participants were excluded due to technological problems and another nine children were excluded because they were unable to complete the inclusion task.

Following Murayama et al.'s (2022) method, we performed a two-tail, one sample t-test a priori power analysis in G*Power (Faul et al., 2007) as a proxy for determining group sample size for a multilevel model. Using d = .32 (based on Girouard-Hallam & Danovitch, 2022), the group sample size at power = .80 is 79. Thus, we had adequate power to proceed with the planned multilevel models.

Participants were recruited through social media advertisements and http://childrenhelpingscience.org. Approximately 84% of participants were identified by their parents as White, 6% as Asian-American, 4% as Black/African-American, and 6% were identified as belonging to two or more races. Ninety percent of participants were identified as non-Hispanic, 7% as Hispanic, and ethnicity information was not provided for 3% of participants. Seventy-nine children were living in the United States and one child participated from India.

Procedure

The study took place over a Zoom video-call.

Time Inclusion Task

In order to ensure that children understood time-related language, participants were asked to order three events on a timeline. These events occurred in the past (e.g., Tom rode his bike yesterday), the present (e.g., Mary is playing with blocks today), and the future (e.g., Grace will listen to music tomorrow). Only children who correctly ordered all three events based on the terms "yesterday," "today" and "tomorrow" were included in the study.

Introduction to Google

The experimenter described Google as "a search engine, which is something that uses the internet in order to answer questions about different things. If you have a question, you can "Google" it. You do this by typing a question into a box on the screen. After you've typed in your question, you can press a button that says "Google Search". Google then searches the internet for websites that might have the answer." This description was accompanied by images of the Google search screen and a sample search output screen (i.e., list of websites).

Informant Evaluation Task

Children were instructed to listen to questions posed by fictional people that were divided into three categories with two items each: past, present, and future events. Questions about past events included the word "yesterday" (e.g., "Tia wants to know what time the store opened yesterday"), questions about the present included the word "today" (e.g., "Sarah wants to know what the traffic is like on Hamilton Road today"), and questions about the future included the word "tomorrow" (e.g., "Hannah wants to know how many babies will be born in the United States tomorrow"). Questions items were designed to be answerable when paired with any of the three time labels, and were piloted with 30 adults to ensure that adults believed they could be answered by one of the sources. Questions were presented in one of two counterbalanced random orders, and the time label associated with each question was also rotated across three orders, for six possible orders. After hearing the target question, children were asked if Google could correctly answer the question (yes/no), if a friend of the fictional person posing the question could correctly answer the question (yes/no), and which informant would have the better answer (Google or the friend) and why. If children initially indicated that neither informant could answer the question, they were still asked to choose which one would have the better answer, and why.

Information Stability Task

After the informant evaluation task, children indicated whether different types of information could change from one day to the next for four items. Two items involved unstable information (e.g., "It was cloudy in Indiana today. Could the weather be different in Indiana tomorrow?") and two items involved stable information (e.g., "This giraffe has brown eyes. Could the giraffe's eye color be different tomorrow?").

Justification Coding

Justifications were transcribed and coded into six categories: knowledge, access to information, prediction ability, accuracy, ability to directly experience an event, and efficiency (see Table 1 for full coding scheme and examples). Responses that were irrelevant or inaudible were not included. Two coders analyzed half of participants' responses with 98% interrater agreement (kappa for all categories = .891). The second half of the data was then coded by one of the two initial coders.

Results

Preliminary analyses did not reveal significant effects of order or gender, so these variables were excluded from further analysis. Children's responses to the Information Stability task were nearly all at ceiling (76 participants answered all questions correctly, and the remaining 4 participants missed only one item) so this measure was also excluded from analyses.

Table 1: Justification codes and examples.

Code	Example
Knowledge	"Google knows about everything."
Information Access	"Google is hooked up to the internet…so it can…see what the traffic is like."
Prediction Capacity	"Maybe Google…will gather up enough information to make an almost accurate prediction of how many people will come."
Direct Experience	"Because Beth can go to the beach and count the number of people."
Accuracy	"Google is normally more accurate than a lot of people."
Efficiency	"Google is more efficient than a person looking outside."

Informant Evaluations

To examine the effects of age, informant, and question type on children's judgments, we developed a generalized linear mixed model (GLMM) using the glmer function with the BOBYQA optimizer in the lme4 package (Bates et al., 2015) in R version 4.0 (R Core team, 2020). The fixed effects in the model were informant (human or Google) and question type (past, present, future), and child age (centered at its mean), was included as a continuous predictor. The model also included 2-way and 3-way interactions between informant, question type, and age, and random intercepts for child and item. Random intercepts were added one a time to the base model (Informant x Question Type x Age) until a model that was parsimonious and explained the most variance was reached. A logit link function was used because the dependent variable was binary. Note that we explored including children's familiarity with search engines in the model but found that this factor did not significantly improve model fit, due to the high level of familiarity (92% of participants had either used a search engine themselves or watched someone else use one). The function "lme.dscores" in the EMAtools R package (Kleiman, 2017) was used to generate Cohen's d values for the significant main effects and interactions. Additionally, chi square values for the overall model and main effects are included.

In the final model, children's endorsements differed by informant, $\chi 2(6) = 222.86$, $B = 2.34$, 95% CI [1.74, 2.95], $p < .001$, $d = .60$, where children were generally more likely to say that Google could answer the question than they were to say that the person could answer the question. There was also a significant main effect of question type, $\chi^2(8) = 72.74$, where children were generally more likely to believe that questions about the past could be answered more often than questions about the present ($B = -0.59$, 95% CI [-1.00, -0.18], $p = 0.005$, $d = .21$) and that questions about the past ($B = -1.64$, 95% CI [-2.06, -1.22], $p < .001$, d=.56) and the present ($B = -1.05$, 95% CI [-1.45, -0.65], $p < .001$, $d = .54$) could be answered more often than questions about the future, regardless of informant.

There was also a significant two-way interaction between Age and Informant, $B = 0.70$, 95% CI [0.19, 1.22], $p = 0.007$, $d = .18$, which was subsumed by a significant three-way interaction between Age, Informant, and Question Type, $B = -0.75$, 95% CI [-1.49, -.01], $p = 0.049$, $d = .14$. These interactions were driven by differences between judgments regarding questions about past events and present events (see Figure 1). Although children's evaluations of each informant's capacity to answer questions about past events did not vary with age, older children were more likely than younger children to indicate that Google could answer questions about present events, and less likely to indicate that the person could do so.

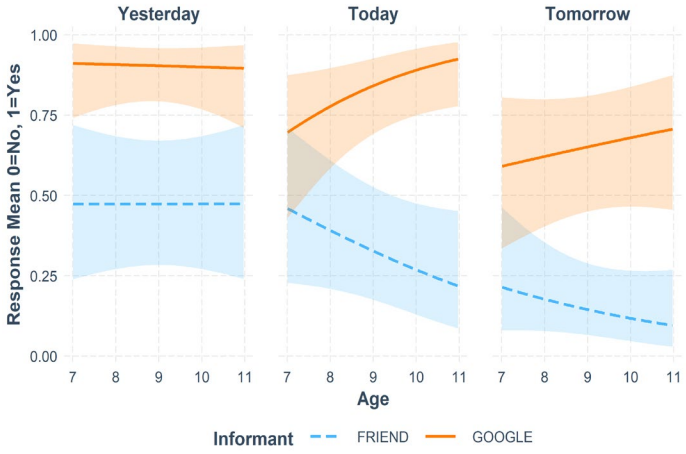

Figure 1: Mean attribution of capacity for Google and the person across Age. CIs are indicated around regression lines.

Forced Choice Trials

To examine the effects of age and question type on children's identification of Google as better at answering the question than the human informant, we developed a generalized linear mixed model (GLMM) in the same way as the Evaluation trials. The fixed effects in the model were question type (past, present, future) and child age (centered at its mean), which was included as a continuous predictor. The model also included 2-way interactions between question type and age, and random intercepts for child and item.

In the final model, children's rates of selecting Google as the better source differed with question type, ($\chi 2(4) = 10.18$), where children were more likely to indicate that Google would be better than a person at answering questions about the future ($M = .86$, $SD = .39$) than for answering questions about the past ($M = .81$, $SD = .38$), $B = 0.73$, 95% CI [0.25, 1.21], $p = 0.003$, $d = .17$. Children's forced-choice responses for questions about the present (M =.83, $SD = .41$) did not significantly differ from the past or future conditions. There was also a significant main effect of age, $B = 0.60$, 95% CI [0.14, 1.06], $p = 0.011$, $d = .32$, where children's choice of Google increased with age. There were no significant interactions between age and question type.

Justifications

Children who chose Google as the superior information source (402 of 480 trials, with less than 1% coded as irrelevant or no response) focused on its access to information, with the largest proportion (49%) of responses relating to information access. Children frequently cited Google's ability to reference the internet and internet-based sources like websites, social media, and YouTube videos. They also cited the ability of experts (e.g., scientists) and laypeople (e.g., mothers) to put information onto the internet, and Google's ability to access information that updates in real time (i.e., as a game is being played). Twenty-three percent of responses focused on Google's knowledge and, at times, children ascribed near-omniscience to it (e.g., "Google knows nearly everything"). Responses more rarely referenced Google's accuracy (7%) or its efficiency (8%), and they often did so in conjunction with responses citing information access or knowledge. In contrast to children's responses when they chose the person (see below), children never referenced Google's ability to directly experience something as a reason for choosing it. Moreover, for questions involving the future, 26% of responses referenced Google's ability to predict events by drawing from previously available information.

In some cases, children who chose Google referenced limitations related to the person in their justifications. Nearly 25% of responses from children who chose Google referenced the person's lack of experience, with many children saying that "if the person could be there, then she could know." Nine percent of responses from children who chose Google also referenced the person's lack of knowledge and 9% stated that the person would have no information access. Some children even mentioned that the person would probably need to consult Google to find the answer. Finally, justifications for choosing Google rarely cited the person's lack of accuracy (4% of trials) or their inability to make predictions (5%).

Overwhelmingly, children who selected the person (78 of 480 trials; 1% irrelevant/no response) justified their choice by citing the person's ability to directly experience phenomena. Over 73% of responses from children who chose the person referenced that the person could directly engage in activities relevant to answering the question (e.g., going to a game). Moreover, 8% of responses indicated that Google could not experience an event and therefore could not accurately provide an answer about what was happening during that event. Children also referenced Google's limitations in relation to information access in 17% of trials. For example, some children felt that although Google could update its information, it could not do so frequently enough to make up for gaps in experience (e.g., "If Tia is at the game she could see the score right away, but Google might not have updated yet.")

To compare justifications by age, individual independent chi square goodness of fit tests were conducted between two age groups (7-8-year-olds and 9-10-year-olds). The results suggested that younger children more frequently ascribed intelligence to the informants ($\chi^2 = 6.43$, $p = .011$). Older children more frequently referenced the information access of the informant than younger children ($\chi^2 = 5.25$, $p = .021$). Older children were also much more likely to reference the potential accuracy of the informant when giving a justification ($\chi^2 = 28.17$, $p < .001$).

Discussion

The current study explored children's evaluations of the Google search engine and a person's capacity to answer questions about past, present, and future events. Children had consistent intuitions about both informants' capacity to answer questions about past events, regardless of their age. Children endorsed Google's capacity to answer questions about the past nearly 2/3rds of the time, but they endorsed the capacity of the person on only about half of trials. These findings suggest that by age 7, children view the the search engine as more capable than the person. Likewise, when children were forced to choose between informants, they overwhelmingly selected Google as the better source of answers to questions about the past. Children as young as age 4 prefer to ask for information from familiar internet-based devices (Wojcik et al., 2021). Children's preference for technological informants may therefore extend from internet-based devices such as voice assistants to internet search engines.

Children's responses to questions about the present significantly differed from their responses to questions about the past and they also varied with age. Older children indicated that Google could accurately answer questions about the present more frequently than younger children did, and they also indicated that the person could answer these questions less frequently. This pattern of responses may relate to the fact that the items in this study involved current events that continuously update (e.g., the score in an ongoing sports game) and older children may have been more sensitive to the changing nature of this type of information than younger children. Although 7-year-olds know that a person may hold false beliefs when information updates without the person's knowledge (e.g., Liu et al., 2008) and they can update their own beliefs in response to new information (Schlottmann, 2017; Schlottmann & Anderson, 1995), children's ability to update their own beliefs (Hagá & Olson, 2017) and use new evidence to modify their reasoning (Schauble, 1990) is still improving between ages 7 and 10. By extension, younger children may be more willing than older children to trust a person's ability to know about a current event because they may think less about how the information might change from moment to moment. Future research should further explore these possibilities.

Additionally, because younger children use the internet less than older children (Rideout & Robb, 2020), older children may view the internet as a broader resource that includes information about present events. Young children do not recognize that internet-based devices, like iPads, can be useful for information about current events like the weather until age 6 (Eisen & Lillard, 2016), and this understanding

may continue to develop with age. Judgments about the internet's scope may be particularly important when considering current events because, unlike with information about the past, to provide answers about current events, the internet must contain more information than facts that can be referenced (i.e., it must also contain constantly updating information). Children's prior experience with the internet and their beliefs about its scope may have in turn impacted their choices in the forced choice condition, such that older children chose Google as having the better answer more often than younger children.

Finally, children were less likely to indicate that a person and Google could provide an accurate answer for questions involving future events than for questions involving past or present events. This finding suggests that they are more skeptical of an informants' ability to prognosticate than to provide information about the past or present. Nevertheless, children selected Google over the person for questions involving future events significantly more often than for questions involving past or present events. It may be that when children are doubtful about either informants' capacity to provide the correct answer, they choose the technological informant as having the better answer.

Although children's skepticism around the ability of both people and Google to answer questions about the future may be unsurprising, children often justified Google's ability to predict a future event in terms of its superior access to past information relative to the person. For example, one child explained that "Neither of them can be exact, but only Google can search how good the team is so far and do it with the other team to see which one is better, and then say that one will probably win." This response suggests that children think about an informants' ability to access information about the past in order to inform predictions about the future. Thus, children not only consider the predictive power of both sources, but they also find technological sources to be better at prediction than people.

Another recurring theme in children's justifications involved direct and indirect access to information. Google is not a primary source; it is a tertiary one. Children often stated that one of Google's advantages is its ability to access other entities such as news websites or weather apps. The perception that experts use websites or apps to provide information may also explain why children more frequently chose Google as the better information source. For instance, in their justifications, some children said that scientists and weathermen put information on the internet that Google could access. However, children also value an informant's capacity for direct observations (Nurmsoo & Robinson, 2009). Children who chose the person as the better source often believed that the person would have direct experience with an event, suggesting that some children may favor direct experience over indirect access to information. Children's understanding that a person might be a better informant than the internet because of a person's ability to experience something (such as whether something tastes good) should be further explored. Moreover, the age-related differences in the forced choice task suggest that younger children valued the person's capacity for direct experience more than older children did. Although recent research suggests that children have some understanding of when an internet-based device is an appropriate source of information and when it is not (Girouard-Hallam & Danovitch, 2022), further research should explore the relation between children's judgments about informants' abilities to answer questions when a technological source's indirect access to information and a person's direct experience are compared, and whether children recognize when a piece of information is more likely to have come from the internet as opposed to a person.

The current study has several limitations. Because children participated via Zoom, they were likely to have previously been exposed to the internet, and to have regular access to the internet in their homes. Children who have less experience using the internet would potentially be more likely than the children in the current study to attribute accuracy to the human informant (a more familiar source of information) and less likely to attribute accuracy to the technological informant (a less familiar source). Additionally, there was a small effect size for the finding that children's intuitions about an informant's capacity to answer questions about present events and past events differed. Further research is needed to elucidate the developmental trajectory of children's recognition that answers to certain questions can change from moment to moment and how it relates to how they evaluate potential sources.

Taken together, our findings suggest that children view the Google search engine as a reliable information source, even for challenging questions like predicting a future event. Moreover, in the absence of explicit information about either informants' epistemic traits, children were more likely to endorse a technological agent's ability to answer questions than a person. Their justifications suggest that some children view information access and knowledgeability as inherent characteristics of a search engine, although their understanding of how these characteristics shape Google's ability to provide information about current events may still be developing during the elementary school years. Our findings also suggest that children may have more difficulty evaluating informants' capacity to provide unstable, transient information than the stable information typically involved in selective trust research. Furthermore, given how frequently children in our study believed Google could provide accurate answers, even to questions about future events, parents and educators should consider guiding or co-viewing children's internet searches to ensure that children understand Google's capacities and limitations.

Acknowledgements

The authors thank the parents and children who participated in this study and the members of the University of Louisville KID Lab for their assistance with data collection and entry. The authors thank Megan Norris for her assistance in justification response coding.

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