

Postprint: Epistemic Trust in Intelligent Voice Assistants Across Different Domains in Children Aged 3-6

Authors: Li Zhe, Liu Zheyu, Mao Keyu, Li Wanting, Li Tingyu, Li Jing

Date: 2023-10-09T00:00:00+00:00

Abstract

Using a dual-information-source experimental paradigm, this study examined epistemic trust in Digital Voice Assistants (DVAs) among children aged 3–6 years and adults, and investigated the role of accuracy in such trust. In Experiment 1, we manipulated information source type (DVAs vs. human) and knowledge domain (natural vs. social). Results showed that, compared with humans, both children and adults exhibited stronger epistemic trust in DVAs. The level of trust in DVAs was higher among 6-year-olds than among 4- and 5-year-olds, and higher among adults than among children. Compared with the social domain, both children and adults were more inclined to ask DVAs questions in the natural domain. Building on Experiment 1, Experiment 2 manipulated the accuracy conditions of testimonies provided by the two information sources. Results revealed that when DVAs were inaccurate, both children and adults no longer trusted their testimonies, and 3-year-olds showed lower sensitivity to accuracy. The findings indicate that information source type, knowledge domain, and testimony accuracy all influence children's epistemic trust, and that accuracy is a crucial criterion for evaluating the reliability of DVAs.

Full Text

Preamble

Acta Psychologica Sinica 2023, Vol. 55, No. 9, 1411–1423

© 2023 Chinese Psychological Society

<https://doi.org/10.3724/SP.J.1041.2023.01411>

The Epistemic Trust of 3- to 6-Year-Olds in Digital Voice Assistants Across Different Domains

Li Zhe¹, Liu Zheyu¹, Mao Keyu¹, Li Wanting¹, Li Tingyu¹, Li Jing^{2,3}

(¹ College of Child Development and Education, Zhejiang Normal University, Hangzhou 311231, China)

(² Institute of Psychology, Chinese Academy of Sciences, Key Laboratory of Behavioral Science, Beijing 100101, China)

(³ Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China)

Abstract

Using a dual-informant experimental paradigm, this study examined the epistemic trust of 3- to 6-year-old children and adults in digital voice assistants (DVAs) and verified the role of accuracy in their trust. In Experiment 1, we manipulated informant type (DVAs vs. humans) and knowledge domain (natural vs. social). The results showed that both children and adults exhibited stronger epistemic trust in DVAs compared to humans. Trust in DVAs was higher among 6-year-olds than among 4- and 5-year-olds, and adults showed greater trust than children. Both children and adults were more inclined to consult DVAs for natural domain questions than for social domain questions. Building on Experiment 1, Experiment 2 manipulated the accuracy conditions of testimony provided by the two informants. The findings revealed that when DVAs were inaccurate, both children and adults ceased to trust their testimony, though 3-year-olds showed lower sensitivity to accuracy. These results indicate that informant type, knowledge domain, and testimony accuracy all influence children's epistemic trust, with accuracy serving as a crucial criterion for evaluating the reliability of DVAs.

Keywords: 3- to 6-year-olds, epistemic trust, DVAs, accuracy, domain specificity

Classification Code: B844

Introduction

In recent years, advances in intelligent voice technology and the proliferation of related products have significantly increased children's opportunities and time to interact with various digital voice assistants (also known as digital language assistants, conversational robots, smart personal assistants, virtual robots, etc., hereafter referred to as DVAs). According to a 2020 Common Sense Media report on children's electronic media usage, 41% of American children aged 0–8 have smart voice devices at home (Rideout, 2020). This represents a dramatic increase from just 9% in 2017 (Rideout, 2017). Concurrently, it is estimated that by the end of 2020, the total number of devices supporting intelligent voice interaction exceeded 4 billion, a figure projected to surpass the world's population by 2024 (Moar & Escherich, 2020). DVAs can automatically recognize children's spoken inquiries and engage in voice-based interaction, eliminating the prerequisite literacy skills required for text-based internet searches (Murray, 2021) and

enabling younger children to interact and learn with DVAs earlier. With their natural human-computer interaction mode and convenient access, DVAs are poised to transform children's learning patterns (Druga et al., 2017). Research indicates that although children can utilize extended functions of DVAs, such as entertainment features like listening to music, their usage frequency for these functions is far lower than their use of DVAs to obtain information—children primarily treat DVAs as information sources rather than entertainment tools (Oranç & Ruggeri, 2021).

Over the past two decades, developmental psychology research has demonstrated that epistemic trust is a crucial pathway for children to acquire knowledge (Zhang & Zhu, 2014). The process through which children learn from information provided by sources is termed epistemic trust, or selective trust, also known as selective social learning. When children ask DVAs questions and obtain information from their voice output to complete learning, this process can be viewed as epistemic trust in DVAs (Girouard-Hallam & Danovitch, 2022a). Within this framework, children's learning process with DVAs can be conceptualized as a process of judging, selecting, and accepting DVA testimony (Zhang & Zhu, 2014; Girouard-Hallam & Danovitch, 2022a).

Girouard-Hallam and Danovitch (2022a) investigated the epistemic trust of 4- to 5-year-old children and 7- to 8-year-old children in DVAs, finding that older children were more inclined to seek factual information from DVAs. However, this study represents the only current investigation of children's epistemic trust in DVAs and suffers from several limitations that necessitate further research. First, the age span of participants was large, resulting in a certain degree of discontinuity and incompleteness. Additionally, considering existing research based on human informants suggesting that children under 4 years may exhibit a "bias to believe"—uncritically accepting information provided by others even when clear evidence indicates the testimony is false (Jaswal et al., 2010; Jaswal et al., 2014; Tong et al., 2020)—it is necessary to examine age differences in children's epistemic trust in DVAs continuously across the 3–6 year age range. Second, in Experiment 1 of that study, DVAs and humans provided identical answers to the same question, after which children judged the correctness of both testimonies. This method would greatly affect the study's validity, as young children might uncritically endorse responses from different informants (Jaswal et al., 2010) or exhibit a tendency to say "yes" (Okanda & Itakura, 2010). Third, although Experiment 2 changed the procedure to have children choose which informant (DVA or human) could provide correct answers, in fact neither informant actually provided testimony. Children did not engage in effective learning interactions with informants during the experiment, making the examination of children's epistemic trust incomplete. Finally, Experiment 2 only included questions about epistemic trust ("Who can give us the right answer?"), but previous research has found that "willingness to ask" is not a reliable indicator of epistemic trust (Li et al., 2018). Ignoring children's process of selecting and endorsing DVA testimony would greatly weaken the study's validity. Therefore, future research should add explicit trust judgment and

final endorsement tasks to comprehensively examine 3- to 6-year-old children's evaluation and endorsement of DVA testimony.

Children's epistemic trust may exhibit domain specificity, manifested as potential differences in epistemic trust toward DVA testimony across different knowledge domains. Many researchers have proposed that children's epistemic trust differs across domains. Zhang et al. (2020) found that in clue-conflict situations, children show different developmental patterns of epistemic trust for natural and social domain knowledge. Girouard-Hallam and Danovitch (2022b) found that for questions about the past or present, 7- to 10-year-old children were more willing to trust information provided by Google, whereas for questions about the future, children believed that neither humans nor Google could provide accurate answers. More recently, Girouard-Hallam and Danovitch (2022a) divided research questions into three dimensions—stable factual information, transient factual information, and personal information—and found that with age, children showed greater trust in stable and transient factual information provided by DVAs, while preferring humans for personal information. By age 7–8, children almost unanimously considered humans to be better informants for personal information questions. However, given the limitations in participant selection in Girouard-Hallam and Danovitch (2022a), whether domain differences exist in children's epistemic trust in DVAs during early childhood remains worth exploring. Additionally, the reason for this domain specificity may be that children recognize different informants have different domain expertise. Research shows that children exhibit stronger trust preferences for informants with professional knowledge—for example, they are more willing to endorse testimony about animals from zookeepers (Boseovski & Thurman, 2014) and weigh more heavily information about medicine and disease causes provided by doctors (Toyama, 2017). Therefore, this study controlled DVA testimony across different domains (natural vs. social) to verify whether children's epistemic trust in DVAs exhibits domain specificity.

In summary, as an information source in the digital age, DVAs present a question worth exploring regarding the development and characteristics of children's epistemic trust. Based on previous research limitations, this study focuses on examining: (1) whether children of different ages can view DVAs as reliable information sources comparable to humans and trust their testimony when facing different informants (DVAs vs. humans); (2) whether children's epistemic trust in DVAs depends on their accuracy—this study manipulates informant accuracy conditions in Experiment 2 to explore whether children still choose to trust information provided by DVAs when they lack accuracy. We predict that accuracy is the core criterion affecting children's epistemic trust in DVAs, meaning that when DVAs are no longer accurate, children's trust preferences will disappear; and (3) whether children's epistemic trust in DVAs differs across domains—this study divides testimony content into natural and social domains to explore domain specificity in children's epistemic trust in DVAs. We predict that in the social domain, children may tend to choose humans, who possess complete social attributes, as the targets for inquiry and endorsement.

Experiment 1: Epistemic Trust of 4- to 6-Year-Olds in DVAs Across Different Domains

Participants

According to G*Power 3.1 calculations, with a significance level of $\alpha = 0.05$ and effect size $w = 0.30$, a minimum sample size of 88 participants was required to achieve 80% statistical power. This experiment recruited 90 children from three age groups at a kindergarten and 30 adult participants (half male, half female). The groups consisted of: 4-year-olds ($n = 30$, $M = 53.33$ months, $SD = 3.06$), 5-year-olds ($n = 30$, $M = 65.70$ months, $SD = 2.80$), 6-year-olds ($n = 30$, $M = 75.60$ months, $SD = 1.72$), and adults ($n = 30$, $M = 21.85$ years, $SD = 7.22$). This experiment was approved by the institutional ethics committee and received consent from the kindergarten. The kindergarten communicated with the children's guardians to obtain informed consent.

Materials

The DVA (Xiaomi speaker)—“Xiaoai”—and a female adult—“Yuanyuan”—served as different types of informants [Figure 1: see original paper]. The informants' testimony provision process was prerecorded video, with the experimenter controlling video playback timing and content during the experiment to make the two informants appear to answer participants' questions in real time.

For the natural domain task, experimental materials consisted of researcher-created pictures of novel objects, with meaningless reduplicated pseudo-words as their names. Children's familiarity with and preference for the experimental material pictures were pre-assessed. Through inquiries with 30 child participants who did not take part in the actual experiment, we ensured that children did not recognize the material pictures and had no preference for either the pictures or the artificial names. Final experimental materials were presented to participants via PowerPoint.

The social domain task involved customary situation stories, adapted from Clément et al. (2004). The stories are shown in . The experimenter first introduced the situational background: “This is our good friend Dingding, but this child belongs to the bongbonglolo ethnic group, and his living habits are very different from ours. He wants to invite you to attend a bongbonglolo festival.” Participants were asked to answer four social domain questions, such as “What special clothing should you wear to attend this festival?” [Figure 2: see original paper]. Questions and answers are presented in .

Procedure

The experiment was conducted in a quiet room at the kindergarten. The experimenter worked one-on-one with each child participant for approximately 10 minutes. The research procedure is illustrated in [Figure 3: see original paper].

Warm-up phase: The experimenter engaged in simple interactions with the child, such as discussing favorite cartoons, friends, and sports, to help the child relax. The experimenter then introduced the game and explained that “Yuanyuan” (human) and “Xiaoai” (DVA) would complete the game together with them.

Willingness-to-ask question: In the natural domain task, the experimenter presented four pictures of novel objects (see) and asked the child, “Do you know what this is?” In the social domain task, the experimenter introduced the problem situation and asked relevant questions (see). After the child expressed not knowing the answer, the experimenter asked, “Both Yuanyuan and Xiaoai know the answer to this question. Who would you like to ask?” Choosing “Xiaoai” was scored as “1” and choosing “Yuanyuan” as “0”.

Testimony provision: The experiment employed a conflicting informant paradigm (Koenig et al., 2004; Koenig & Harris, 2005). “Yuanyuan” and “Xiaoai” served as informants, providing children with names for four novel objects (see) or advice on what to do in four situations (see). The order of picture presentation, sequence of social situation tasks, position of informants, testimony provided, and order of testimony delivery were all counterbalanced in advance.

Explicit trust question: The experimenter asked the child, “Who do you think is right? Who do you trust?” If the child did not answer or did not make a clear judgment, the experimenter repeated both informants’ testimony and asked the child to choose whether they trusted Yuanyuan’s or Xiaoai’s testimony. Choosing “Xiaoai” was scored as “1” and “Yuanyuan” as “0”.

Final judgment question: The experimenter asked the child, “Now, what do you think this object is?/What do you think should be done?” The experimenter recorded the child’s response. Cognitive judgments consistent with Xiaoai’s testimony were scored as “1” and those consistent with Yuanyuan’s as “0”.

Debriefing phase: The experimenter briefly explained the research purpose, thanked the child, gave a gift, and escorted the child back to their classroom.

Design

The experiment employed a 4 (age: 4-year-olds/5-year-olds/6-year-olds/adults) $\times$ 2 (informant: human vs. DVA) $\times$ 2 (question domain: natural vs. social) mixed factorial design. Age and question domain were between-subjects variables, while informant was a within-subjects variable. The dependent variables were participants’ choices of which informant to ask, which testimony to trust, and whether participants’ final judgments aligned with which informant (DVA vs. human).

Statistical Analysis

In this study, the dependent variables were repeated-measures categorical data (children's willingness to ask, explicit trust, and final judgments regarding informants), with data following a binomial distribution. Therefore, we used the glmer function with the BOBYQA optimizer from the lme4 package in R version 4.2.2 to establish generalized linear mixed models (GLMM) for statistical analysis.

Results and Discussion

Informant Selection Analysis of children's and adults' average willingness to ask DVAs in the natural and social domains is shown in [Figure 4: see original paper]. Using children's epistemic trust in DVAs (willingness to ask) across domains (natural vs. social) as the dependent variable, the full GLMM included the following fixed effects: age, domain, and the age $\times$ domain interaction. Random factors included child ID and trial. Through principal component analysis, we sequentially reduced random slopes and intercepts. The final model showed a significant main effect of domain ($\chi^2 = 3.85$, $df = 1$, $p = 0.050$) and a significant main effect of age ($\chi^2 = 60.12$, $df = 3$, $p < 0.001$). The domain $\times$ age interaction was not significant ($\chi^2 = 3.85$, $df = 3$, $p = 0.084$). Post-hoc comparisons for domain revealed that children were significantly less willing to ask DVAs questions in the social domain than in the natural domain ($t = 2.19$, $p = 0.029 < 0.05$, $d = 0.14$). Post-hoc comparisons for age showed that adults were more willing than children to ask DVAs (adult–4-year-olds: $t = 9.39$, $d = 0.72$; adult–6-year-olds: $t = 5.11$, $p < 0.001$, $d = 0.54$). Older children were more inclined to ask DVAs than younger children (5-year-olds–4-year-olds: $t = 2.30$, $p = 0.022 < 0.05$, $d = 0.19$; 6-year-olds–4-year-olds: $t = 4.28$, $p < 0.001$, $d = 0.36$; 6-year-olds–5-year-olds: $t = 1.98$, $p = 0.048 < 0.05$, $d = 0.17$).

These results indicate that both adults' and children's initial trust preferences for DVAs are influenced by question domain, with both groups more inclined to initially ask DVAs about natural domain questions than social domain questions. Additionally, adults are more willing than children to ask DVAs initially, and older children show increasing preference for asking DVAs.

Explicit Trust Analysis of children's and adults' average explicit trust in DVAs across domains is shown in [Figure 5: see original paper]. Using children's epistemic trust in DVAs (explicit trust) across domains as the dependent variable, the full GLMM included fixed effects of age, domain, and their interaction. Random factors included child ID and trial. After reducing random slopes and intercepts through principal component analysis, the final model showed no significant main effect of domain ($\chi^2 = 0.45$, $df = 1$, $p = 0.502$) but a significant main effect of age ($\chi^2 = 32.37$, $df = 3$, $p < 0.001$). The domain $\times$ age interaction was not significant ($\chi^2 = 2.68$, $df = 3$, $p = 0.443$). Post-hoc comparisons for age revealed that adults were more willing than children to trust DVAs (adult–4-year-olds: $t = 10.48$, $p < 0.001$, $d = 1.12$; adult–5-year-olds:

$t = 10.59$, $p < 0.001$, $d = 1.13$; adult–6-year-olds: $t = 6.62$, $p < 0.001$, $d = 0.79$). Six-year-olds were more willing to trust DVAs than 4- and 5-year-olds (6-year-olds–4-year-olds: $t = 3.86$, $p < 0.001$, $d = 0.31$; 6-year-olds–5-year-olds: $t = 3.97$, $p < 0.001$, $d = 0.32$).

These results indicate that adults are more willing than children to trust DVAs, and 6-year-olds are more willing to trust DVAs than 4- and 5-year-olds.

Final Endorsements Analysis of children’s and adults’ average final judgments in the natural and social domains is shown in [Figure 6: see original paper]. Using children’s epistemic trust in DVAs (final judgments) across domains as the dependent variable, the full GLMM included fixed effects of age, domain, and their interaction. Random factors included child ID and trial. After reducing random slopes and intercepts, the final model showed no significant main effect of domain ($\chi^2 = 1.81$, $df = 1$, $p = 0.178$) but a significant main effect of age ($\chi^2 = 33.49$, $df = 3$, $p < 0.001$). The domain $\times$ age interaction was not significant ($\chi^2 = 0.20$, $df = 3$, $p = 0.978$). Post-hoc comparisons for age revealed that adults were more willing than children to ultimately trust DVAs (adult–4-year-olds: $t = 10.67$, $p < 0.001$, $d = 1.15$; adult–5-year-olds: $t = 10.46$, $p < 0.001$, $d = 1.13$; adult–6-year-olds: $t = 7.41$, $p < 0.001$, $d = 0.86$). Compared with 4- and 5-year-olds, 6-year-olds were more willing to ultimately trust DVAs (6-year-olds–4-year-olds: $t = 3.27$, $p = 0.001$, $d = 0.26$; 6-year-olds–5-year-olds: $t = 3.05$, $p = 0.002 < 0.01$, $d = 0.25$).

These results indicate that adults are more willing than children to ultimately accept DVA testimony. Six-year-olds’ final judgments aligned with their explicit trust, showing greater willingness to ultimately accept DVA testimony compared to 4- and 5-year-olds.

Overall, these results demonstrate that trust in DVAs increases with age. All children show growing trust in DVAs as they get older, with 6-year-olds trusting DVAs more than 4- and 5-year-olds. Adults trust DVAs more than children. This aligns with our predictions, indicating that with increasing age and social experience, children increasingly view DVAs as better information providers. Both adults and children are more inclined to initially ask DVAs about natural domain questions than social domain questions, consistent with previous findings that children’s epistemic trust for natural and social domain testimony differs (Corriveau et al., 2014; Einav et al., 2013; Clément et al., 2004; Zhang et al., 2020). Previous research also shows that young children (3-year-olds) already understand that knowledge is domain-specific and that informants’ knowledge represents a division of cognitive labor (Keil et al., 2008). Children may believe that in the natural domain, DVAs and their underlying internet and artificial intelligence have greater professional authority than humans. Given that DVAs may also provide incorrect and untrue testimony, if accuracy is children’s core criterion for judging DVA reliability, then a crucial question is whether children still consider DVAs trustworthy when they lose accuracy. Therefore, Experiment 2 manipulates the accuracy of DVAs and humans to verify whether

accuracy is the core standard children use to evaluate DVA credibility. Since Experiment 1 showed that 4-year-olds already possess rational epistemic trust decision-making abilities similar to older children and adults, while previous research suggests that children under 4 may be more prone to credulity (Jaswal et al., 2010; Jaswal et al., 2014; Tong et al., 2020), it is necessary to extend the age range downward to 3-year-olds to examine developmental patterns. Based on this, Experiment 2 expands the participant age range to include 3-year-olds to investigate epistemic trust in DVAs among younger children.

Experiment 2: Accuracy-Based Epistemic Trust of 3- to 5-Year-Olds in DVAs Across Different Domains

Participants

According to G*Power 3.1 calculations, with a significance level of $\alpha = 0.05$ and effect size $w = 0.30$, a minimum sample size of 88 participants was required to achieve 80% statistical power. This experiment recruited 90 children from three age groups at a kindergarten and 30 adult participants (half male, half female). The groups consisted of: 3-year-olds ($n = 30$, $M = 44.77$ months, $SD = 2.57$), 4-year-olds ($n = 30$, $M = 56.43$ months, $SD = 3.57$), 5-year-olds ($n = 30$, $M = 65.60$ months, $SD = 3.56$), and adults ($n = 30$, $M = 21.70$ years, $SD = 7.11$). No participants had taken part in Experiment 1. This experiment was approved by the institutional ethics committee and received consent from the kindergarten. The kindergarten communicated with the children's guardians to obtain informed consent.

Materials

Materials were essentially the same as in Experiment 1, with the addition of a familiarization phase after the warm-up phase. During the familiarization phase, the accuracy history of informants was manipulated [Figure 7: see original paper].

Warm-up phase: Identical to Experiment 1.

Familiarization phase: The experimenter told children they would be shown several pictures, and that “Xiaoai” and “Yuanyuan” would tell them what the pictures were. Children were randomly assigned to either the “Xiaoai inaccurate, Yuanyuan accurate” condition or the “Xiaoai accurate, Yuanyuan inaccurate” condition. In the “Xiaoai inaccurate, Yuanyuan accurate” condition, the experimenter told children that Yuanyuan would always provide “correct” answers while Xiaoai would provide “wrong” answers. Conversely, for children in the “Xiaoai accurate, Yuanyuan inaccurate” condition, Xiaoai was the reliable information source.

The experimenter then presented three familiar object pictures consecutively (see). The accurate informant always answered correctly, while the inaccurate informant always answered incorrectly. For example, when shown a picture of

“pants,” the accurate informant identified them as “pants,” while the inaccurate informant answered “shoes.” The order of picture presentation, position of informants, informant accuracy, and order of testimony delivery were all counterbalanced in advance.

Test phase and debriefing phase: Identical to Experiment 1.

Design

The experiment employed a 4 (age: 3-year-olds/4-year-olds/5-year-olds/adults) $\times$ 2 (accuracy condition: “Xiaoai inaccurate, Yuanyuan accurate” vs. “Xiaoai accurate, Yuanyuan inaccurate”) $\times$ 2 (question domain: natural vs. social) mixed factorial design. The accuracy condition was selected from four possible combinations of 2 (accuracy: accurate vs. inaccurate) $\times$ 2 (informant: human vs. DVA). Given that this experiment manipulated differences in accuracy between two informants, conditions where both humans and DVAs were accurate or both were inaccurate were excluded. Age, accuracy condition, and domain were between-subjects variables. The dependent variables were participants’ choices of which informant to ask, which testimony to trust, and whether participants’ final judgments aligned with DVA “Xiaoai” (yes vs. no).

Statistical Analysis

Similar to Experiment 1, this study used the glmer function with the BOBYQA optimizer from the lme4 package in R version 4.2.2 to establish generalized linear mixed models for statistical analysis.

Results and Discussion

Informant Selection Analysis of children’s and adults’ average willingness to ask DVAs in the natural and social domains under different accuracy conditions is shown in [Figure 8: see original paper]. When DVAs lost their accuracy, the average willingness to ask DVAs decreased across all three child age groups and adults in both natural and social domains.

Using children’s epistemic trust (willingness to ask) toward informants with different accuracy (accurate vs. inaccurate) across domains as the dependent variable, the full GLMM included the following fixed effects: accuracy condition, age, domain, and all two-way interactions. Random factors included child ID and trial. We attempted to include the three-way interaction of accuracy condition $\times$ age $\times$ domain in the model, but the model failed to converge, so it was not included in the final model. Through principal component analysis, we sequentially reduced random slopes and intercepts. The final model showed no significant main effect of domain ($\eta^2 = 0.05$, $df = 1$, $p = 0.815$) and no significant main effect of age ($\eta^2 = 1.55$, $df = 3$, $p = 0.672$). The main effect of accuracy condition was significant ($\eta^2 = 97.57$, $df = 1$, $p < 0.001$), as was the accuracy condition $\times$ age interaction ($\eta^2 = 25.66$, $df = 3$, $p < 0.001$). Neither the accuracy condition $\times$ domain ($\eta^2 = 0.11$, $df = 1$, $p = 0.738$) nor the age $\times$ domain ($\eta^2 =$

1.81, $df = 3$, $p = 0.613$) interactions were significant. The accuracy condition $\times$ age interaction is illustrated in [Figure 9: see original paper].

Post-hoc comparisons for accuracy condition revealed that children were more willing to ask accurate informants ($t = 28.62$, $p < 0.001$, $d = 1.85$), regardless of whether they were human or DVA. Simple effects analysis of the accuracy condition $\times$ age interaction showed that adults and all three child age groups were more willing to ask accurate informants (adults: $p < 0.001$; 3-year-olds: $p < 0.001$; 4-year-olds: $p < 0.001$; 5-year-olds: $p < 0.001$). In the “Xiaoai inaccurate, Yuanyuan accurate” condition, adults were more willing than children in all three age groups to ask accurate informants (adult–3-year-olds: $p = 0.010$; adult–4-year-olds: $p = 0.002 < 0.001$; adult–5-year-olds: $p = 0.033 < 0.05$), with no significant differences among child age groups (3-year-olds–4-year-olds: $p = 0.999$; 3-year-olds–5-year-olds: $p = 0.725$; 4-year-olds–5-year-olds: $p = 0.606$). In the “Xiaoai accurate, Yuanyuan inaccurate” condition, adults were more willing than 4-year-olds to ask accurate informants ($p < 0.001$), with no significant differences among child age groups (3-year-olds–4-year-olds: $p = 0.406$; 3-year-olds–5-year-olds: $p = 0.999$; 4-year-olds–5-year-olds: $p = 0.265$).

These results indicate that under manipulated accuracy conditions, both adults and children prefer to ask accurate informants. Compared to children, adults are more willing to ask accurate informants.

Explicit Trust Analysis of children’s and adults’ average explicit trust in DVAs across domains under different accuracy conditions is shown in [Figure 10: see original paper]. When DVAs lost their accuracy, explicit trust in DVAs decreased across all three child age groups and adults in both natural and social domains.

Using children’s epistemic trust (explicit trust) toward informants with different accuracy across domains as the dependent variable, the full GLMM included fixed effects of accuracy condition, age, domain, and all two-way interactions. Random factors included child ID and trial. After reducing random slopes and intercepts, the final model showed no significant main effect of domain ($\eta^2 = 0.26$, $df = 1$, $p = 0.612$). The main effect of age was significant ($\eta^2 = 8.10$, $df = 3$, $p = 0.044 < 0.05$), as was the main effect of accuracy condition ($\eta^2 = 103.29$, $df = 1$, $p < 0.001$). Neither the accuracy condition $\times$ age ($\eta^2 = 1.29$, $df = 3$, $p = 0.731$), accuracy condition $\times$ domain ($\eta^2 = 3.13$, $df = 1$, $p = 0.077$), nor age $\times$ domain ($\eta^2 = 1.16$, $df = 3$, $p = 0.762$) interactions were significant. Post-hoc comparisons for age revealed that compared to 3-year-olds, 4-year-olds, 5-year-olds, and adults all showed greater preference for trusting accurate informants (4-year-olds–3-year-olds: $t = 2.85$, $p = 0.004 < 0.01$, $d = 0.26$; 5-year-olds–3-year-olds: $t = 3.95$, $p < 0.001$, $d = 0.36$; adults–3-year-olds: $t = 2.02$, $p = 0.043 < 0.05$, $d = 0.18$). Post-hoc comparisons for accuracy condition showed that children were more likely to trust accurate informants ($t = 41.27$, $p < 0.001$, $d = 2.67$).

These results indicate that under manipulated accuracy conditions, both adults and children prefer to trust accurate informants. Compared to 3-year-olds, 4-year-olds, 5-year-olds, and adults all show stronger preferences for trusting accurate informants.

Final Endorsements Analysis of children's and adults' average final judgments across domains under different accuracy conditions is shown in [Figure 11: see original paper]. When DVAs lost their accuracy, final judgments aligned with DVAs decreased across all three child age groups and adults in both natural and social domains.

Using children's epistemic trust (final judgments) toward informants with different accuracy across domains as the dependent variable, the full GLMM included fixed effects of accuracy condition, age, domain, and all two-way interactions. Random factors included child ID and trial. After reducing random slopes and intercepts, the final model showed no significant main effect of domain ($\chi^2 = 0.19$, $df = 1$, $p = 0.662$) and no significant main effect of age ($\chi^2 = 3.96$, $df = 3$, $p = 0.265$). The main effect of accuracy condition was significant ($\chi^2 = 88.39$, $df = 1$, $p < 0.001$). Neither the accuracy condition $\times$ age ($\chi^2 = 2.81$, $df = 3$, $p = 0.422$), accuracy condition $\times$ domain ($\chi^2 = 3.79$, $df = 1$, $p = 0.051$), nor age $\times$ domain ($\chi^2 = 0.60$, $df = 3$, $p = 0.897$) interactions were significant. Post-hoc comparisons for accuracy condition revealed that children were more likely to ultimately trust accurate informants ($t = 42.79$, $p < 0.001$, $d = 2.76$).

These results indicate that under manipulated accuracy conditions, both adults and children prefer to trust accurate informants.

The results of Experiment 2 demonstrate that both children and adults across different domains show greater willingness to trust accurate informants. In other words, children use the real-time accuracy of informants as a cue to judge and select which informant to trust. When DVAs lose accuracy, children's preference and epistemic trust in them disappear. This strongly supports our hypothesis that children's epistemic trust in DVAs depends on DVA accuracy. Detailed analysis reveals that compared to 3-year-olds, 4-year-olds, 5-year-olds, and adults show more pronounced preferences for trusting accurate informants, while 3-year-olds show lower sensitivity to accuracy. This aligns with Jaswal et al. (2014), suggesting that with age and cognitive development, children's ability to judge information accuracy increases. Additionally, ages 3–6 represent a period of rapid development in children's inhibitory control; during rational information judgment, children must inhibit their trust preference for DVAs and use accuracy as the judgment criterion. Furthermore, the results show that even 3-year-olds can make epistemic trust judgments based on informant accuracy, consistent with Danovitch and Alzahabi (2013).

Children's epistemic trust in DVAs exhibits domain specificity. This study modified the experimental paradigm and materials based on previous research, using a conflicting informant paradigm (Koenig et al., 2004; Koenig & Harris, 2005)

to examine the development of Chinese 3- to 6-year-olds' epistemic trust in DVAs across different domains and to explore the impact of DVA accuracy on children's epistemic trust. The results largely support our hypotheses.

Age differences exist in children's epistemic trust in DVAs. Experiment 1 results show that children of different ages exhibit different preferences for epistemic trust in DVAs, with older children showing greater willingness to trust DVAs initially. This may occur because as children grow older, they gain more understanding of DVAs and increasingly view them as reliable information sources. Particularly in explicit trust and final judgment questions, 6-year-olds were more willing than 4- and 5-year-olds to choose DVAs as informants. We can also observe that 6-year-olds' decisions are approaching those of adults, indicating maturation. Under conditions manipulating intelligent voice assistant accuracy, Experiment 2 results show that compared to 3-year-olds, 4- and 5-year-olds and adults all show stronger preferences for trusting accurate DVAs. In the "Xiaoai inaccurate, Yuanyuan accurate" condition, 5-year-olds' decisions already approached those of adults. These findings align with our hypotheses, indicating that with age and cognitive development, children in the later preschool period can rationally judge and choose which informant testimony to trust.

DVA accuracy determines children's epistemic trust. Building on Experiment 1, Experiment 2 manipulated the accuracy conditions of DVA and human testimony. The results show that children and adults of all ages are more likely to accept accurate informant testimony in both natural and social domains. In other words, children are more likely to use informants' real-time accuracy as a cue to evaluate and decide which informant to trust, and when DVAs lose accuracy, children's epistemic trust preference disappears. This strongly confirms our hypothesis that children's epistemic trust in DVAs depends on DVA accuracy. Detailed analysis shows that compared to 3-year-olds, 4- and 5-year-olds and adults exhibit more pronounced trust preferences for accurate informants, while 3-year-olds show lower sensitivity to accuracy. This aligns with Jaswal et al. (2014), suggesting that with age and cognitive development, children's ability to judge information accuracy increases. Meanwhile, ages 3–6 represent a period of rapid development in children's inhibitory control; during rational information judgment, children must inhibit their trust preference for DVAs and use accuracy as the judgment criterion. Furthermore, the results indicate that even 3-year-olds can make epistemic trust judgments based on informant accuracy, consistent with Danovitch and Alzahabi (2013).

Children's epistemic trust in DVAs shows domain specificity. In the natural domain, 5- and 6-year-olds and adults showed higher average willingness to ask, average selective trust, and average final judgments for DVAs than in the social domain. This aligns with our hypothesis, indicating that with age and social experience, children can judge who is a better informant. When social domain questions are involved, children gradually recognize that humans with complete social attributes can provide more reasonable answers, or that humans

are experts in the social domain. The study also found that 4-year-olds showed higher average willingness to ask and average selective trust for DVAs in the natural domain than in the social domain, but in final judgments, 4-year-olds showed trust preferences for DVAs in the natural domain. We speculate that this inconsistency may occur because social domain tasks are more complex than natural domain tasks, and 4-year-olds' cognitive abilities are insufficient for accurate, rapid judgment of obtained information. This finding also indicates that 4-year-olds can already conduct complex analysis and judgment of obtained information, recognizing that different informants have different domain expertise and selecting informants with higher domain expertise accordingly. Under conditions manipulating DVA and human accuracy, neither adults nor children showed domain specificity, with both groups preferring to trust accurate informants in both natural and social domains. This further suggests that DVA accuracy may be a prerequisite for children's epistemic trust in DVAs, with accuracy being a more important characteristic of good informants than children value.

However, this study also has limitations. First, this study completed experimental design and data collection before the publication of Girouard-Hallam and Danovitch (2022a), so it did not reference their attribution trials, instead focusing on exploring the impact of different domain information and accuracy on children's epistemic trust in DVAs. Future research could ask children about their attributions regarding DVAs to further explore this topic. Second, although research shows that children's preferences for informants are unrelated to whether they have DVAs at home (Girouard-Hallam & Danovitch, 2022a), we believe that investigating the development of children's epistemic trust in DVAs should still control for familiarity with both DVAs and humans. This study did not pre-test or post-test whether children had DVAs at home, and relying solely on foreign researchers' data cannot substitute for DVA ownership rates in Chinese families. Future research should survey whether participants' families own DVAs. Additionally, this study used artificially synthesized novel objects as experimental materials in the natural domain and created fictional ethnic groups and festivals in the social domain, limiting ecological validity.

Conclusion

- (1) Age differences exist in children's epistemic trust in DVAs, with older children showing greater trust in DVAs. Compared to children, adults are more willing to trust DVAs.
- (2) Accuracy is an important criterion for both children and adults in their epistemic trust of DVAs; children and adults only show epistemic trust preferences for accurate DVAs.
- (3) Children's and adults' epistemic trust in DVAs exhibits domain specificity, with both groups more willing to ask DVAs natural domain questions than

social domain questions.

References

- Boseovski, J. J., & Thurman, S. L. (2014). Evaluating and approaching a strange animal: Children's trust in informant testimony. *Child Development*, 85(2), 824–834.
- Clément, F., Koenig, M., & Harris, P. (2004). The ontogenesis of trust. *Mind & Language*, 19(4), 360–379.
- Corriveau, K., & Harris, P. L. (2009). Preschoolers continue to trust a more accurate informant 1 week after exposure to accuracy information. *Developmental Science*, 12(1), 188–198.
- Corriveau, K. H., Einav, S., Robinson, E. J., & Harris, P. L. (2014). To the letter: Early readers trust print-based over oral instructions to guide their actions. *British Journal of Developmental Psychology*, 32(3), 345–358.
- Danovitch, J. H., & Alzahabi, R. (2013). Children show selective trust in technological informants. *Journal of Cognition and Development*, 14(3), 499–513.
- Druga, S., Williams, R., Breazeal, C., & Resnick, M. (2017, June). “Hey Google is it ok if I eat you?” Initial explorations in child-agent interaction. In *Proceedings of the 2017 conference on interaction design and children* (pp. 595–600). Stanford, California.
- Einav, S., Levey, A., Patel, P., & Westwood, A. (2020). Epistemic vigilance online: Textual inaccuracy and children's selective trust in webpages. *British Journal of Developmental Psychology*, 38(4), 566–579.
- Einav, S., Robinson, E. J., & Fox, A. (2013). Take it as read: Origins of trust in knowledge gained from print. *Journal of Experimental Child Psychology*, 114(2), 262–274.
- Girouard-Hallam, L. N., & Danovitch, J. H. (2022a). Children's trust in and learning from voice assistants. *Developmental Psychology*, 58(4), 646–661.
- Girouard-Hallam, L. N., & Danovitch, J. H. (2022b). Children's judgments about asking for past, present, and future information from Google and a person. In *Proceedings of the Annual Meeting of the Cognitive Science Society*, 44(44). California.
- Girouard-Hallam, L. N., Streble, H. M., & Danovitch, J. H. (2021). Children's mental, social, and moral attributions toward a familiar digital voice assistant. *Human Behavior and Emerging Technologies*, 3(5), 1118–1131.
- Jaswal, V. K. (2006). Preschoolers favor the creator's label when reasoning about an artifact's function. *Cognition*, 99(3), 83–92.
- Jaswal, V. K., Carrington Croft, A., Setia, A. R., & Cole, C. A. (2010). Young children have a specific, highly robust bias to trust testimony. *Psychological*

Science, 21(10), 1541–1547.

Jaswal, V. K., Pérez Edgar, K., Kondrad, R. L., Palmquist, M., Cole, C. A., & Cole, C. E. (2014). Can't stop believing: Inhibitory control and resistance to misleading testimony. *Developmental Science*, 17(6), 965–976.

Kahn Jr, P. H., Gary, H. E., & Shen, S. (2013). Children's social relationships with current and near-future robots. *Child Development Perspectives*, 7(1), 32–37.

Keil, F. C., Stein, C., Webb, L., Billings, V. D., & Rozenblit, L. (2008). Discerning the division of cognitive labor: An emerging understanding of how knowledge is clustered in other minds. *Cognitive Science*, 32(2), 259–300.

Kinzler, K. D., Corriveau, K. H., & Harris, P. L. (2011). Children's selective trust in native-accented speakers. *Developmental Science*, 14(1), 106–111.

Koenig, M. A., Clément, F., & Harris, P. L. (2004). Trust in testimony: Children's use of true and false statements. *Psychological Science*, 15(10), 694–698.

Koenig, M. A., & Harris, P. L. (2005). Preschoolers mistrust ignorant and inaccurate speakers. *Child Development*, 76(6), 1261–1277.

Landrum, A. R., Mills, C. M., & Johnston, A. M. (2013). When do children trust the expert? Benevolence information influences children's trust more than expertise. *Developmental Science*, 16(4), 622–638.

Li, Q.-G., Heyman, G. D., Xu, F., & Lee, K. (2014). Young children's use of honesty as a basis for selective trust. *Journal of Experimental Child Psychology*, 117, 59–72.

Li, T. Y., Liu, L., Li, Y. L., & Zhu, L. Q. (2018). Preschoolers' selective trust and belief revision in conflicting situation. *Acta Psychologica Sinica*, 50(12), 1390–1399.

Liu, D., Vanderbilt, K. E., & Heyman, G. D. (2013). Selective trust: Children's use of intention and outcome of past testimony. *Developmental Psychology*, 49(3), 439–445.

Moar, J., & Escherich, M. (2020). *Hey siri, how will you make money*. Juniper Research. Retrieved January 27, 2023, from <https://www.juniperresearch.com/whitepapers/hey-siri-how-will-you-make-money>

Murray, G. W. (2021). Who is more trustworthy, Alexa or mom?: Children's selective trust in a digital age. *Technology, Mind, and Behavior*, 2(3), 1–12.

Okanda, M., & Itakura, S. (2010). Do bilingual children exhibit a yes bias to yes-no questions? Relationship between children's yes bias and verbal ability. *International Journal of Bilingualism*, 14(2), 227–235.

Oranç, C., & Ruggeri, A. (2021). “Alexa, let me ask you something different” children's adaptive information search with voice assistants. *Human Behavior and Emerging Technologies*, 3(4), 595–605.

- Rideout, V. (2017). *The common sense census: Media use by kids age zero to eight*. San Francisco, CA: Common Sense Media.
- Rideout, V. (2020). *The common sense census: Media use by kids age zero to eight*. San Francisco, CA: Common Sense Media.
- Tong, Y., Wang, F., & Danovitch, J. (2020). The role of epistemic and social characteristics in children's selective trust: Three meta-analyses. *Developmental Science*, 23(2), e12895.
- Toyama, N. (2017). Development of the selection of trusted informants in the domain of illness. *Infant & Child Development*, 26(6), e2039.
- Xu, F., Evans, A. D., Li, C., Li, Q., Heyman, G., & Lee, K. (2013). The role of honesty and benevolence in children's judgments of trustworthiness. *International Journal of Behavioral Development*, 37(3), 257–265.
- Xu, Y., & Warschauer, M. (2020, April). What are you talking to?: Understanding children's perceptions of conversational agents. In *Proceedings of the 2020 CHI conference on human factors in computing systems* (pp. 1–13). Honolulu.
- Yarosh, S., Thompson, S., Watson, K., Chase, A., Senthilkumar, A., Yuan, Y., & Brush, A. B. (2018, June). Children asking questions: Speech interface reformulations and personification preferences. In *Proceedings of the 17th ACM conference on interaction design and children* (pp. 300–312). Trondheim, Norway.
- Zhang, J., Li, T. M., Zheng, Q. T., Zhou, S. Z., & Xiong, H. X. (2020). Preschoolers' selective trust characteristics of knowledge in different domains in the clue conflict situation. *Journal of Psychological Science*, 43(2), 371–377.
- Zhang, Y. H., & Zhu, L. Q. (2014). Epistemic trust: How preschoolers selectively learn from others. *Advances in Psychological Science*, 22(1), 86–96.

The Epistemic Trust of 3- to 6-Year-Olds in Digital Voice Assistants in Various Domains

Li Zhe¹, Liu Zheyu¹, Mao Keyu¹, Li Wanting¹, Li Tingyu¹, Li Jing^{2,3}

(¹ College of Child Development and Education, Zhejiang Normal University, Hangzhou 311231, China)

(² Institute of Psychology, Chinese Academy of Sciences, Key Laboratory of Behavioral Science, Beijing 100101, China)

(³ Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China)

Abstract

A new generation of interactive models, called digital voice assistants (DVAs), can respond to young children's speech requests automatically and interact with them by voice. Research on the development of young children's epistemic trust

in DVAs is scarce. Previous research has concentrated on the development and influencing factors of young children's epistemic trust in human informants or traditional electronic media (e.g., computers, webpages, internet). The semisocial nature of these devices determines the specific theoretical and practical value of investigating young children's epistemic trust in DVAs. Based on this, the purpose of the current study was to investigate the epistemic trust of young children (aged 3-6) and adults in DVAs in various domains and to confirm the significance of accuracy in their trust.

The paradigm of dual-informant sources was employed in both experiments. A sample size of 88 children was required for an effect size of $w = 0.30$, $1 - \beta = 0.8$, $\alpha = 0.05$, according to G*Power 3.1. In Experiment 1, 30 adults and 90 children aged 4-6 were given testimony from distinct information sources (DVAs vs. humans) in either the natural or social domain to investigate the children's willingness to ask questions, explicit trust judgments, and final endorsements. Whereas the natural domain involved a task to label novel things, the social domain involved inquiry into social customs. The accuracy of the informants was manipulated in Experiment 2, which was based on Experiment 1, and 90 children aged 3-5 and 30 adults were exposed to various informants.

The research participants were asked questions about their willingness to ask, explicit trust judgments, and final endorsements. The results of Experiment 1 showed that the children preferred to ask the DVAs questions about the natural domain rather than the social domain, with the DVAs being preferred overall. Moreover, the 6-year-old children preferred the DVAs as the information source more than the 4- to 5-year-old children. The adults were more likely to trust the DVAs than the young children. The results of Experiment 2 revealed that the children of all ages and adults were more likely to accept correct informant testimony in both the natural and social domains. In other words, the children were more likely to use the current accuracy of informants as a cue to assess and decide which informant to trust, and when the DVAs lost their accuracy, the children's preference disappeared along with their intellectual trust. The preference for accurate informants was more obvious in the adults and 4- to 5-year-olds than in the 3-year-olds, with the 3-year-olds being less sensitive to accuracy. Accuracy was an essential indicator of the DVAs' dependability.

Our study is the first to investigate the development of epistemic trust in DVAs among children aged 3-6 in China. The results show that children can use DVAs as a source of information and knowledge. Young children become more likely to believe the testimonies of DVAs as they grow older. Children are more likely to trust DVAs in the natural domain than in the social domain. Furthermore, young children are more likely to accept the testimony of reliable informants. The results of this study may contribute to our understanding of the usability and utility of human interaction with technological systems and offer suggestions for the use of DVAs in homes and classrooms to support early learning.

Keywords: 3- to 6-year-olds, epistemic trust, digital voice assistants (DVAs), accuracy, domain specificity

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.