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Developing expectations regarding the boundaries of expertise

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ABSTRACT

Three experiments examined elementary school-aged children's and adults' expectations regarding what specialists (i.e., those with narrow domains of expertise) and generalists (i.e., those with broad domains of expertise) are likely to know. Experiment 1 demonstrated developmental differences in the ability to differentiate between generalists and specialists, with younger children believing generalists have more specific trivia knowledge than older children and adults believed. Experiment 2 demonstrated that children and adults expected generalists to have more underlying principles knowledge than specific trivia knowledge about unfamiliar animals. However, they believed that generalists would have more of both types of knowledge than themselves. Finally, Experiment 3 demonstrated that children and adults recognized that underlying principles knowledge can be generalized between topics closely related to the specialists' domains of expertise. However, they did not recognize when this knowledge was generalizable to topics slightly less related, expecting generalists to know only as much as they would. Importantly, this work contributes to the literature by showing how much of and what kinds of knowledge different types of experts are expected to have. In sum, this work provides insight into some of the ways children's notions of expertise change over development. The current research demonstrates that between the ages of 5 and 10, children are developing the ability to recognize how experts' knowledge is likely to be limited. That said, even older children at times struggle to determine the breadth of an experts' knowledge.

1. Introduction

It is important for individuals to take a critical stance towards sources of new information by evaluating cues indicating whether he or she is likely to be accurate (Mills, 2013). One such cue is whether a source has relevant *expert* knowledge (e.g., Aguiar, Stoess, & Taylor, 2012; Koenig & Jaswal, 2011; Landrum, Mills, & Johnston, 2013; Lutz & Keil, 2002). People turn to experts for advice because they believe experts to be knowledgeable (e.g., Bohner, Ruder, & Erb, 2002; Chaiken, 1987). In fact, when people lack enough background knowledge (or motivation) to evaluate the content of a claim, they often use the source's expertise as a heuristic to determine how much to believe the claim (e.g., peripheral route processing, Haugtvedt & Petty, 1992; Petty, Cacioppo, & Goldman, 1981).

Given that children often have less background knowledge than adults, the ability to use expertise as a proxy for claim accuracy becomes particularly important. After all, since children recognize that adults generally possess more knowledge than themselves, they may be prone to trust all information from all adults (e.g., Mossler, Marvin, & Greenberg, 1976; Wimmer & Hogrefe, 1988). Yet as all adults are not experts in all topics, it is crucial that children

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recognize when someone has relevant expert knowledge and when she does not. The goal of the current set of experiments is to examine children's expectations regarding the boundaries of expertise—what they expect different experts to know and to what extent they expect experts' knowledge to be limited—and how these expectations change across development. Successful recognition of expertise, and subsequent inference about knowledge, can assist children in finding and trusting the most accurate information.

The preliminary skills necessary for evaluating expertise begin to appear during infancy and develop over the preschool years. By 14–16 months, infants recognize when someone produces statements that are incongruent with the world (e.g., Koenig & Echols, 2003). By age 4, children begin to reason about others' mental states: recognizing, for example, when someone lacks access to knowledge (e.g., Pillow, 1989; Robinson, Champion, & Mitchell, 1999) or believes something that is inaccurate (e.g., Wellman & Liu, 2004). By age 5, children become more adept at evaluating potential sources of information, at least when choosing between obviously accurate and inaccurate informants (e.g., Koenig & Harris, 2005). For instance, this age group has demonstrated an ability to track an informant's accuracy and use that information to (1) make inferences about an informant's relative knowledgeability and helpfulness (e.g., Shafto, Eaves, Navarro, & Perfors, 2012), (2) determine whether to endorse new information provided by an informant (e.g., Birch, Vauthier, & Bloom, 2008; DiYanni & Keleman, 2008; Koenig & Harris, 2005; Scofield & Behrend, 2008), and (3) determine whether to seek information from the informant (e.g., Mills, Legare, Bills, & Mejias, 2010; Mills, Legare, Grant, & Landrum, 2011).

Yet, people are not often presented with a choice between a clearly accurate and a clearly inaccurate (or ignorant) informant; thus it is also important for children to differentiate between two knowledgeable sources who simply vary on *what* they are knowledgeable about, as is the case with experts. Evaluating experts requires understanding that someone's knowledge can be limited to what is *relevant* to that person's area of expertise. This understanding begins during the preschool years and develops through the elementary school years.

Preschoolers, in some circumstances, can attribute knowledge to the most relevant expert available (e.g., Lutz & Keil, 2002). For example, when asked to compare a bicycle expert and an eagle expert, 3-, 4-, and 5-year-olds attributed bird-related knowledge to eagle experts over bicycle experts and vehicle-related knowledge to bicycle experts over eagle experts (Lutz & Keil, 2002). Moreover, 4- and 5-year-olds attributed knowledge from a broader category to the most relevant expert (e.g., saying that bicycle experts are more likely than eagle experts to know about mechanical things, such as elevators; Lutz & Keil, 2002). Beyond attributing knowledge, when these two experts provided conflicting claims about a series of novel objects, 4- and 5-year-old children preferred to trust the claims provided by the more relevant expert (i.e., trusted the eagle expert's claims about bird-related objects and the bicycle expert's claims about vehicle-related objects; Landrum et al., 2013, Experiment 1).[1] Thus, as preschoolers are somewhat able to use relevancy to organize knowledge domains, they are demonstrating the beginning of another skill important for evaluating experts: understanding how knowledge clusters together.

Although research has demonstrated that preschoolers start to think about how knowledge clusters together, the bulk of this ability develops between ages 6 and 10 (the elementary school years). Particularly noteworthy, between the ages of 8 and 10, children shift from preferring to think of expertise as grouping by topic (clustering around information relevant to a single topic of interest; e.g., eagles, bicycles) to recognizing that expertise can group by discipline (clustering by knowledge of deep, often causal, underlying principles relevant to a discipline such as biology or physics; Danovitch & Keil, 2004; Keil, Stein, Webb, Billings, & Rozenblit, 2008).

Although previous literature describes a developmental trajectory in understanding expertise, due to the paradigms used by the majority of these studies, it is unclear from the current literature what children understand about the boundaries of someone's expertise—how an expert's knowledge might be incomplete or limited, and how these expectations might change across development.

In the vast majority of studies investigating both preschool-aged and elementary-aged children's understanding of expertise, two different experts (or two knowledge items) have been pitted against one another in a forced-choice paradigm (e.g., Danovitch & Keil, 2004; Keil et al., 2008; Landrum et al., 2013; Lutz & Keil, 2002; Sobel & Corriveau, 2010). In this kind of paradigm, children either have to determine which of two experts has the best answer to one question or which of two items one expert is more likely to know about. However, recognizing that one expert knows more than another expert about a given topic, for example, tells us nothing about expectations regarding how much each expert knows on his or her own. These paradigms tell us about expectations regarding *relative* knowledge levels, not absolute ones. For instance, a child could believe that an eagle expert knows a lot about birds while a bicycle expert knows just *marginally less*, or that an eagle expert knows a lot about birds while a bicycle expert knows *nothing*. Both would lead to the same result within the aforementioned paradigm. In fact, researchers using a different paradigm in which preschoolers were asked whether one expert has one bit of knowledge found that 4- and 5-year-olds attributed knowledge to an expert that was unrelated to that expert's area of expertise (attributing mechanical expertise to a child described as an animal expert; Taylor, Esbensen, & Bennett, 1994). Thus, children may have more difficulty recognizing the limitations to an informant's expertise when they are asked to evaluate whether that individual has the appropriate knowledge to answer a question than when they are asked to choose the better of two options.

[1] Although, this ability is somewhat tenuous (e.g., Boseovski & Thurman, 2013; Landrum et al., 2013, Experiments 2 & 3).

Similarly, research examining elementary schoolers' understanding of expertise suggests that this age group expects knowledge to cluster in different ways depending on the breadth of expertise. That is, children often expect experts with broader domains of expertise (i.e., generalists; e.g., animal experts, vehicle experts) to have knowledge clustering by discipline (e.g., based on an understanding of underlying biological or mechanical principles), whereas they expect experts with narrower domains of expertise (i.e., specialists; e.g., poodle experts, police car experts) to have knowledge clustering either by discipline or topic (e.g., cross-discipline knowledge of everything having to do with a specific topic such as poodles or police cars; Keil et al., 2008). However, this research also used the forced-choice paradigm described above. With regard to generalists, children were asked to choose which one of two pieces of information a generalist (e.g., an animal expert) is likely to know: an example of discipline-centered underlying principles (e.g., why dolphins need to have hearts to keep them alive) or an example of topic-centered trivia (e.g., why dolphins are in an exhibit at Sea World), and they tended to choose underlying principles knowledge over specific trivia knowledge (Keil et al., 2008; Study 6). But this tells us nothing about how much of each kind of knowledge they think the generalist knows, or if they think the generalist knows any specific trivia at all. To demonstrate that children think it is unlikely for generalists to have specific trivia knowledge, they would have to be given the opportunity to say whether it is likely for a generalist to know one, both, or neither knowledge type (i.e., underlying principles, specific trivia).

With regard to specialists, this research has shown that children, when asked to choose which one of two pieces of information a specialist is likely to know (underlying principles or specific trivia), choose at chance levels. But this could be because children were unsure of what these experts know or because they thought specialists know about both underlying principles and specific trivia. Therefore, although prior research seems to indicate that children sense boundaries (or limitations) to different types of experts' knowledge, it is possible that children are merely demonstrating that they understand which knowledge most relates to which expertise.

Given that the paradigm used by most studies of children's evaluations of expertise might have led to misconceptions about what children understand, there are several open questions on this topic. First, in a paradigm where children are asked to evaluate one expert's knowledge of one item (i.e., a single expert/single item paradigm), will children expect two experts with overlapping domains of expertise (i.e., a generalist and a specialist) to have different amounts and types of knowledge? Second, will children expect that a generalist is unlikely to have specific trivia knowledge? Third, what are children's intuitions about specialists' knowledge: are children, indeed, uncertain about what these experts know? Fourth, given the developmental shift between 8 and 10 found by prior, similar work (e.g., Danovitch & Keil, 2004), will a developmental shift between 8 and 10 be found with regard to each of these research questions? Moreover, how do children's intuitions about expertise compare with the likely more sophisticated ones of adults?

1.1. Research overview

The current research aims to answer these questions by examining 6- to 10-year-old children's expectations regarding the boundaries of expertise—how children in each of these age groups expect two experts who vary in their breadth of expertise (i.e., generalists versus specialists) might be limited in their depth of knowledge (i.e., knowledge type: underlying principles versus specific trivia). This age range was chosen as prior work (described in Section 1) shows that this is the developmental period in which children begin to think about expertise in a slightly more sophisticated way.

These kinds of experts – generalists and specialists – were chosen in part because they may parallel experts seen in everyday life, such as a primary care physician versus an ear, nose, and throat physician or a zookeeper versus a dolphin handler. For the purposes of this line of work, though, we felt it important to begin by testing novel experts from prior studies (e.g., animal experts; Keil et al., 2008) to avoid over or under attribution of knowledge due to social biases regarding various professions (e.g., children might be prone to thinking experts such as medical doctors know more than what is relevant to their expertise because the position has high social standing). Because we do not know for certain what these novel experts would know in real life, instead of comparing children's intuitions of experts' knowledge to what the experts would really know, we compared children's intuitions to the intuition of a sample of adults.

To compare adults' and children's expectations regarding the boundaries of expertise, three experiments were conducted. Experiment 1 asked participants to evaluate the knowledge of both generalists and specialists—determining to what extent each expert is likely to have knowledge of underlying principles and specific trivia. Experiment 2 focused solely on generalists, examining adults' and children's attributions of underlying principles and specific trivia about unfamiliar topics. Experiment 3 focused solely on specialists, examining to what extent adults and children see specialists' knowledge as generalizable to related topics of expertise.

For each of the experiments, adults and children were asked how much they think an expert (either a generalist or specialist) knows about the answer to two questions: one requiring underlying principles knowledge and one requiring specific trivia knowledge. Importantly, we used a single expert/single item paradigm in which children were asked to evaluate whether one expert knows about one item at a time. This way, participants were given the opportunity to attribute each type of knowledge to each type of informant, and independent scores for each knowledge type (underlying principles and specific trivia) attributed to each source (generalists and specialists) were able to be analyzed. Thus, it was possible to determine how much of what types of knowledge children think each expert possesses.

2. Experiment 1

2.1. Method

Experiment 1 aimed to determine whether participants expect two types of experts with overlapping knowledge (i.e., generalists and specialists) to have different types and/or amounts of knowledge and whether these expectations vary by age.

Given this, we hypothesized that the most sophisticated expectations (i.e., those of the adults) would include believing that generalists and specialists have similar amounts of principles knowledge, but that generalists have much less specific trivia knowledge than specialists. We also hypothesized that children's expectations would vary from adults, with children being less sensitive to the distinction between generalists and specialists, perhaps even attributing similar levels of specific trivia knowledge to both. That said, we anticipated that these expectations would vary developmentally such that older children would be more likely than younger children to recognize that generalists would be limited in their trivia knowledge.

2.1.1. Participants

Participants were 20 6-year-olds (M_{age} = 6.01; SD = 0.35; 5 females), 20 8-year-olds (M_{age} = 8.05; SD = 0.65; 14 females), 20 10-year-olds (M_{age} = 10.31; SD = 0.79; 12 females), and 20 adults (M_{age} = 22.29; SD = 5.72; 12 females) and were recruited from the greater North Dallas area to participate. The sample was predominately white and middle class.

2.1.2. Procedure

The procedure consisted of two parts (i.e., training and testing) and was the same for adults and children.

2.1.2.1. Training. Participants were told that they were going to play a game about experts. First, participants were asked, "Do you know what an expert is?" If they did not, it was explained that, "an expert is someone who knows a lot about something." Then, participants were asked to think of some examples of experts (e.g., doctors, car mechanics). Similar methods for introducing experts have been used by previous research (e.g., Danovitch & Keil, 2004; Keil et al., 2008). Following this, participants were told that they were going to hear about some different kinds of experts and were going to be asked whether each expert knows about some different things.

2.1.2.2. Testing. After training, participants were shown a picture book consisting of 18 hand-drawn experts, 16 for test items plus 2 for post-test items. Of the 16 experts, 8 were generalists labeled at the superordinate level of categorization (i.e., "animal experts" and "automobile experts") and 8 were specialists labeled at the subordinate levels of categorization (e.g., "poodle experts" and "police car experts"; for an explanation of levels of categorization see Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Half of the generalists and specialists were drawn as females and half as males.

Participants were introduced to one expert at a time. This consisted of viewing a picture of the expert and hearing descriptions of that person's expertise. For example, when introducing one of the animal generalists, the experimenter would say, "This is Jasmine. Jasmine knows all about animals. She is an animal expert." The corresponding image showed a girl in the middle of the page surrounded by a variety of animals. When introducing one of the specialists, the experimenter would say, for example, "This is Abby. Abby knows all about poodles. She is a poodle expert." The corresponding image for the poodle expert showed a girl in the middle of the page surrounded by poodles.

After being introduced to an expert, participants were asked to evaluate if that expert would have knowledge of two items: one requiring discipline-centered underlying principles knowledge (i.e., referred to here as underlying principles or more simply as principles) and one requiring topic-centered trivia knowledge (i.e., referred to here as specific trivia or more simply as trivia).[2] Using the animal generalist, Jasmine, as an example, participants were asked "Does Jasmine know why poodles that live in the same house are more likely to get the same sickness than poodles that live in different houses?" (a principles item) and were encouraged to answer "yes" or "no".[3] If children said "yes", they were asked whether they thought that the expert knew "a little bit" or "a lot" about that item. Then, participants were asked whether they thought the expert would know about the second item, for example, "why poodles are the national dog of France?"(a trivia item). Both the principles and trivia items for both types of experts (generalists and specialists) referred to the specialists' topics of expertise (both an animal expert and a poodle expert were asked about knowledge referring to poodles, see Table 1). We did this because prior work used similar wording (e.g., Keil et al., 2008) and because in everyday life, when people direct questions to experts, those questions often refer to specific instances as opposed to more general ones (e.g., asking a veterinarian a question about your dog, not about animals in general). This process was repeated for each of the principles and trivia items for the 18 experts. As participants were asked two questions for each of the 18 experts, participants answered a total of 36 items. See Table 1 for a list of the items.

Children were asked each item in the list twice: once for a generalist (i.e., animal expert; vehicle expert) and once for the specialist to which the expertise was relevant—specialists were always paired with items that mentioned their specific domain of expertise (e.g., participants were asked if poodle experts knew about poodle items). The two experts answering the same questions were always gender-matched. Two between-subject expert orders were generated in a list randomizer with the stipulation that children were not asked the same question twice in a row.

[2] The order of these 2 questions (the underlying principles item and the specific trivia item) was counterbalanced between each of the 18 experts and between participants.

[3] If participants responded with "I don't know", they were encouraged to choose one way or the other, consistent with prior work (e.g., Landrum et al., 2013; Johnston, Mills, & Landrum, submitted for publication).

Table 1
Experiment 1 items.

Domain	Knowledge type	
	Underlying principles	Specific trivia
Animal		
Persian cat	Why a baby Persian cat can have blue eyes when both of its parents have brown eyes	Why Persian cats are used in so many cat food commercials
Duck	Why ducks need to eat in order to have enough energy to swim	Why Mississippi considers the duck its state bird
Poodle	Why poodles in the same house are more likely to get the same sickness than poodles that live in different houses	Why poodles are the national dog of France
Turkey	Why baby turkeys grow inside eggs, but some other baby animals grow inside their moms	Why Benjamin Franklin wanted to make the turkey the national mascot of America
Vehicle		
Garbage truck	Why it takes bigger brakes to stop a garbage truck than a regular car	Why garbage trucks were introduced in Europe before the United States
School bus	Why kids fall forward when a school bus stops really fast	Why school busses were changed to be yellow in 1939
Police car	Why a police car siren sounds higher when it is coming up behind you and lower as it passes you and gets farther away	Why police cars in Sweden have black roofs
Sports car	Why a black sports car feels hotter than a yellow sports car	Why a lot of sports cars are made in Italy

The item set used here was adapted from one developed by Keil et al. (2008, study 6) with some modifications.[4] Following the test-items were two additional experts, for each of which children answered 2 post-test items, each of which consisted of a target item and a control item (described in more detail below).[5] These questions were counterbalanced between participants and paralleled the structure of the test items so that participants would not think of these as different from the questions that they had been answering. The post-test items aimed to capture potential associative errors when attributing knowledge. For one target item (i.e., the "improbable" item), participants were introduced to a chair expert and asked if he knows "how many rocking chairs are in the world at this very second," a question that should receive a "no" response due to its implausibility. To parallel the structure of the test items, participants were also asked a second, control item that should have received a "yes" response (see Table 2). For the other target item (i.e., the "homophone" item), participants were introduced to an expert on the State of Maine and asked if she knows how many inches a horse's mane can grow, a question that should receive a "no" response because it is irrelevant to the expert's domain of expertise, even if it sounds the same (could be associated auditorily). Like for the improbable item, participants were asked a control item that should receive a "yes" response (see Table 2).

2.2. Results and discussion

The goal of Experiment 1 was to determine whether participants view two types of experts with overlapping domains of expertise (i.e., generalists and specialists) as having different types and/or amounts of knowledge and whether these expectations vary by age. To test this, a preliminary omnibus, mixed-design ANOVA was conducted with age (6-, 8-, 10-year-olds, and adults) as a between-participants variable and expert (generalist, specialists), domain (animal, vehicle), and knowledge type (principles, trivia) as within-participants variables. The dependent variable was the average amount of knowledge attributed to an expert on a scale of 0–2 (where "no" knowledge answers were scored as 0, knows "a little" answers were scored as 1, and knows "a lot" answers were scored as 2; see Table 3 for significant main effects and interactions from this ANOVA).

Table 2
Experiment 1 post-test and control items.

Domain	Knowledge type	
	Improbable item	Control item
Chairs	How many chairs there are in the world at this very second	How many pieces of wood it takes to make a chair
	Homophone item	Control item
Maine	How many inches a horse's mane can grow	How many people live in Maine

Table 3
Significant main effects and interactions from Experiment 1.

Effect	F	p	η_p^2
Interaction: *Expert* × *Knowledge type* × *Age*	8.71	$p < .001$	.256
Main effect: *Expert*	53.15	$p < .001$	.412
Interaction: *Expert* by *Age*	8.14	$p < .001$	.243
Main effect: *Knowledge type*	100.12	$p < .001$	.568
Interaction: *Knowledge type* by *Age*	6.12	$p = .001$	.243
Interaction: *Expert* by *Knowledge type*	8.14	$p < .001$	.195
Main effect: *Domain*	11.10	$p = .001$	.127
Interaction: *Domain* by *Knowledge type*	1.31	$p = .025$	.064

[4] We used automobile items instead of items about metals for the physical domain because this domain has been used in prior research (Landrum et al., 2013; Lutz & Keil, 2002) and we aimed to use a domain for which the underlying principles knowledge involved physical principles (e.g., motion, conservation of energy).

[5] The control items were added so that the format of the test-items would parallel the post-test items: for each expert presented, two questions were asked, and these questions were counterbalanced between participants.

Table 4
Knowledge attributions to generalists and specialists per age group and the Cohen's *d* effect sizes for the differences. Standard deviations in parentheses.

	Principles knowledge			Trivia knowledge		
	Specialist	Generalist	*d*	Specialist	Generalist	*d*
6-year-olds	1.36(0.65)	1.26(0.62)	0.16	1.18(0.61)	1.16(0.63)	0.04
8-year-olds	1.54(0.36)	1.39(0.44)	0.38	1.17(0.36)	1.15(0.39)	0.05
10-year-olds	1.64(0.27)	1.39(0.39)	0.74	1.34(0.42)	0.95(0.43)	0.91
Adults	1.69(0.33)	1.52(0.27)	0.56	1.38(0.44)	0.72(0.52)	1.36
All ages	1.56(0.44)	1.39(0.62)	0.32	1.27(0.47)	0.99(0.52)	0.56

2.2.1. Test items: comparing children's expectations to adults' expectations

As anticipated, the ANOVA revealed a 3-way interaction between age, expert, and knowledge type, suggesting that there were indeed developmental differences in how participants attributed the two types of knowledge to the two types of experts. Because we were most interested in whether the participants perceived differences between specialists and generalists, we followed up on the three-way interaction by examining the effect of expert (difference between knowledge attributed to specialists and generalists) across the age groups first for principles knowledge and then for trivia knowledge. Note that all the following follow-up tests (simple-effects ANOVAs and *t*-tests) were corrected for multiple comparisons.

To examine age differences in whether participants perceived a difference between specialists and generalists when attributing underlying principles knowledge, we began by conducting a simple-effects ANOVA with expert as a within-participants variable and age as a between-participants variable. The dependent variable was the amount of underlying principles knowledge attributed on the scale of 0–2. The ANOVA revealed a main effect of expert such that participants attributed more principles knowledge to specialists ($M = 1.56$, $SD = 0.44$) than to generalists ($M = 1.39$, $SD = 0.45$), $F(1,3) = 22.27$, $p < .001$, $\eta_p^2 = .227$. However, this effect did not vary across age, $F(1,3) = 0.749$, $p = .527$, $\eta_p^2 = .029$.[6] See Table 4.

Additionally, we used simple-effects ANOVAs to examine whether there were age differences in the amount of principles attributed to each expert. For generalists, we found no age differences: each of the age groups attributed similar amounts of principles knowledge, $F(3,76) = 1.07$, $p = .366$, $\eta_p^2 = .04$. For specialists, we found only a trend towards age differences in the amount of principles knowledge attributed, $F(3,76) = 2.29$, $p = .085$, $\eta_p^2 = .08$.

Next, to examine age differences in whether participants perceived a difference between specialists and generalists when attributing specific trivia knowledge, we conducted a second simple-effects ANOVA with expert as a within-participants variable and age as a between-participants variable. The dependent variable was the amount of specific trivia knowledge attributed on the scale of 0–2. Like with attributions for principles knowledge, the ANOVA revealed a main effect of expert type, such that participants attributed more trivia knowledge to specialists ($M = 1.27$, $SD = 0.47$) than to generalists ($M = 0.99$, $SD = 0.52$), $F(1,3) = 43.76$, $p < .001$, $\eta_p^2 = .365$.[7] Moreover, unlike with principles knowledge, this effect did vary across age (age by expert interaction), $F(1,3) = 14.12$, $p < .001$, $\eta_p^2 = .358$. Post-hoc analyses using the Scheffé post hoc criterion for significance indicated that the younger two age groups (6- and 8-year-olds) attributed more similar levels of trivia knowledge for the two expert types than the older two age groups did (10-year-olds and adults, $p < .05$).

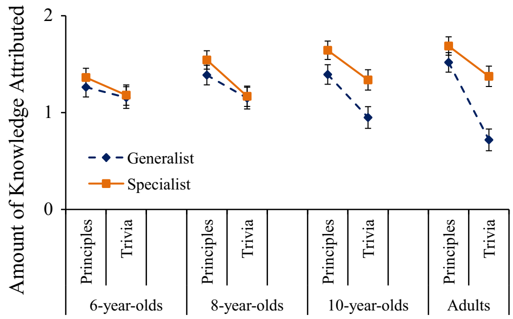

Fig. 1. Expert by knowledge type by age interaction. Amount of specific trivia and underlying principles knowledge attributed to generalists and specialists.

Additionally, we used simple-effects ANOVAs to examine whether there were age differences in the amount of trivia attributed to each expert. For generalists, we did find age differences in the amount of trivia knowledge attributed, $F(3,76) = 3.42$, $p = .021$, $\eta_p^2 = .12$. Follow-up Bonferroni-corrected *t*-tests showed that 6-year-olds attributed more trivia to the generalists than adults ($p = .043$, $d = .78$), and so did 8-year-olds ($p = .048$, $d = .96$). No other groups varied from one another (for means and standard deviations, see Table 4). For specialists, however, we found no age differences: each of the age groups attributed similar amounts of principles knowledge, $F(3,76) = 1.02$, $p = .387$, $\eta_p^2 = .03$. See Fig. 1.

Given the above findings, it seems that that the way that children attribute knowledge to these two expert types generally shifts between age 8 and 10, with 10-year-olds starting to attribute knowledge similarly to adults. Ten-year-olds and adults attribute more of both principles and trivia knowledge to specialists than to

[6] Also, the ANOVA showed no significant main effect of age, indicating that the age groups generally attributed roughly equivalent amounts of knowledge overall, $F(1,3) = 1.78$, $p = .157$, $\eta_p{}^2 = .066$.

[7] Also like with principles knowledge, the ANOVA showed no significant main effect of age, indicating that the age groups generally attributed roughly equivalent amounts of knowledge overall, $F(1,3) = 0.31$, $p = .815$, $\eta_p{}^2 = .012$.

Table 5
Participants' responses to the post-test items by age group.

	Improbable item				Homophone item			
	0 (no) (%)	1 (a little) (%)	2 (a lot) (%)	Average	0 (no) (%)	1 (a little) (%)	2 (a lot) (%)	Average
6yos	40	10	50	1.10	35	30	35	1.00
8yos	75	15	10	0.35	25	45	30	1.05
10yos	85	10	5	0.20	70	15	15	.45
Adult	70	25	5	0.35	85	15	0	.15

generalists. But most crucially, unlike the younger two age groups, 10-year-olds and adults expected that generalists are going to be somewhat limited in their knowledge of specific trivia.

2.2.2. Post-test items

As previously described, we also asked participants two post-test items (i.e., the improbable knowledge item and the homophone item) that aimed to capture possible errors that are likely to occur if participants are merely associating topics with domains of expertise instead of thinking about knowledge in terms of existing in the minds of others.

2.2.2.1. Improbable knowledge item. Most of the adults said a chair expert would have no knowledge about how many chairs there are in the world at this very second (see Table 5), and the average amount of improbable knowledge they attributed to the chair expert was equal to 0.35 out of 2 ($SD = 0.59$). This was significantly less than the amount of control knowledge attributed to the chair expert ("how many pieces of wood does it take to make a chair", $M = 1.70$ out of 2, $SD = .57$, $t(19) = 9.00$, $p < .001$, $d = 2.33$). Thus, adults generally recognized that it was unlikely for an expert to have improbable knowledge, even if it is domain-relevant.

Although 6-year-olds' responses were much more mixed, the majority of 8- and 10-year-olds said a chair expert would have no knowledge about how many chairs there are in the world at this very second (see Table 5). When comparing the average amount of knowledge endorsed for the improbable item versus the control item, 6-year-olds merely trended towards attributing less knowledge for improbable item ($M = 1.10$, $SD = .97$) than for the control item ($M = 1.50$, $SD = .76$), $t(19) = 1.798$, $p = .088$, $d = .46$; whereas both 8- and 10-year-olds attributed less improbable knowledge than control knowledge (both $ps < .001$, $ds > 2.00$). Moreover, only 6-year-olds differed significantly from adults in the amount of improbable knowledge they attributed ($p = .008$, $d = .93$).[8] Thus, by age 8, children seem to grasp that experts are not likely to have improbable knowledge, even if it is domain-relevant. This finding lends support to the idea that children are taking into consideration the fact that knowledge exists in the minds of others, as opposed to simply associating topics with domains of expertise.

2.2.2.2. Homophone item. Our other post-test item asked participants whether an expert would have knowledge regarding a topic that is a homophone of the expert's domain of expertise (i.e., asking whether an expert on the state of *Maine* would know how long a horse's *mane* can grow). This post-test item allowed us to examine if participants were attending to whether the item is conceptually related to the expert's domain of expertise as opposed to associating the topics because they sound the same.

As with the previous post-test item, the majority of adults said an expert on the state of Maine would not know how long a horse's mane could grow and no adults attributed "a lot" of knowledge on this topic. Thus, the average amount of homophone knowledge (across adults) attributed to the Maine expert was equal to 0.15 out of 2 ($SD = 0.37$). This was significantly less than the amount of control knowledge attributed to the Maine expert ("how many people live in Maine", $M = 2.00$ out of 2, $SD < .001$, $t(19) = 22.58$, $p < .001$, $d = 7.07$). Thus, adults generally seemed to be attending to the item, choosing not to attribute knowledge that merely sounded similar in topic.

Children, on the other hand, seemed to struggle more with this item (see Table 5). In fact, the two younger age groups did not attribute knowledge differently for the homophone item and the control item (6yos: $M_H = 1.10$, $SD_H = 0.858$, $M_C = 1.30$, $SD_C = 0.98$, $t(19) = 1.674$, $p = .110$, $d = 0.22$; 8yos: $M_H = 1.05$, $SD_H = 0.76$, $M_C = 0.70$, $SD_C = 0.80$, $t(19) = 1.505$, $p = .149$, $d = 0.45$). The 10-year-olds, however, did attribute knowledge differently for the homophone item ($M = 0.45$, $SD = 0.76$) and control item ($M = 1.40$, $SD = 0.94$), $t(19) = 3.226$, $p = .004$, $d = 1.11$. In retrospect, we realize that it is unclear from our results whether children (a) were attributing knowledge because the topics sounded the same, (b) were attributing this knowledge because they believe that experts know a lot about all types of different things, even when they fall outside of their expertise, or (c) were attributing this knowledge because they believe that "how long a horse's mane can grow" is a fact easily knowable for people, even those who are not experts.

2.3. Open questions

The results from Experiment 1 suggest that what is developing in comparing generalists and specialists along underlying principles and specific trivia knowledge is an expectation of how much specific trivia a generalist is likely to know. Given that generalists, such as animal experts, have expertise that covers a wide breadth of topics

[8] Notably, 6-year-olds differed from both the 8-year-olds ($p = .008$, $d = 1.02$) and the 10-year-olds ($p = .001$, $d = 1.15$). None of the other age groups differed from one another (all $ps = 1.00$).

(7.77 million species of animals), it seems improbable that they would have specific trivia knowledge about every single one of those topics, even though, categorically, the subordinate topics that this specific trivia knowledge falls under the superordinate topic of "animal." Yet, children and adults did not necessarily perceive generalists having specific trivia knowledge as improbable—at least, not as improbable as they perceived having knowledge of the improbable post-test item. For example, if participants expected generalists' knowledge of specific trivia to be equally improbable as a chair experts' knowledge of exactly how many chairs exist in the world at this very second, they might have attributed trivia knowledge to generalists more similarly to how they attributed the improbable knowledge post-test item. Yet this was not the case even for the oldest two age groups—adults attributed significantly more trivia knowledge to generalists ($M = 0.72$) than they attributed improbable ($M = 0.15$) and homophone knowledge (0.35) in the post-test items (both $ps < .02$, $ds > 0.71$). Similarly, 10-year-olds attributed more trivia knowledge to the generalists ($M = 0.95$ of 2) than they attributed improbable ($M = 0.20$) and homophone knowledge ($M = 0.45$) in the post-test items (both $ps < .008$, both $ds > .80$). Therefore, one open question is why participants might believe that generalists can have any (if even only a little) trivia knowledge. Experiment 2 (discussed in more detail in Section 3) aims to begin to address this question.

Also of interest, in Experiment 1, participants generally assumed that specialists would have more knowledge than generalists. Participants attributed high amounts of both knowledge types to the specialists, and there were no significant age differences in the amount of underlying principles knowledge or the amount of specific trivia knowledge attributed to the specialists. These findings extend prior work in an important way. Past research demonstrated that when children were asked whether a specialist was more likely to know underlying principles or specific trivia, they responded at chance levels (e.g., Keil et al., 2008). The current research suggests that children were not responding at chance because they did not know what a specialist was likely to know; instead, they believe that specialists know a lot about both. Still, within Experiment 1 it is difficult to discern if participants perceived *any* limitations to specialists' expertise along topic or type of knowledge. These issues are explored in Experiment 3.

3. Experiment 2

As previously stated, given that generalists have expertise that covers a wide range of topics, it seems improbable that they would have specific trivia knowledge about every single one of those topics. Yet, participants in Experiment 1, particularly the younger ones, attributed some trivia knowledge to the generalists, and all of the age groups seemed to think an animal expert would have more knowledge about specific trivia than a chair expert would have knowledge about something that is improbable to know (i.e., the improbable post-test item).

We hypothesize that two factors could be contributing to why participants attributed specific trivia knowledge to the generalists. On one hand, participants could assume that generalists are likely to know specific trivia because (a) the information itself is knowable, unlike our improbable post-test item from Experiment 1, or (b) they believe that generalists are likely to know at least a little bit about anything that can be categorized under the superordinate category that represents the generalists' domains of expertise. In other words, participants might expect an animal expert to have at least some knowledge of anything that is knowable and can be categorized with the broader topic of "animal" either by discipline (e.g., biological principles) or by topic (e.g., facts about different types of animals). In contrast, participants might have thought that generalists would have some trivia knowledge because the topics chosen for each of the items were familiar enough that it is likely experts in related fields (if not people more generally) would know something about specific trivia associated with these familiar topics—similarly to what we think may have happened with our homophone post-test item. If the latter is the case, then participants would demonstrate that they expect an expert's knowledge to be limited when asked about less familiar examples—maybe even similar amounts to what they would expect themselves (i.e., laypersons) to know. However, if the former is the case, it should not matter that we used unfamiliar animals: participants should be just as likely to attribute trivia knowledge in Experiment 2 as they were in Experiment 1.

Additionally, in Experiment 1, we only collected measures of how much the participants thought that the experts knew and not how confident they were about those ratings. In fact, participants may have granted some trivia knowledge to the generalists because they were less certain about whether generalists would know those items, but they may have defaulted to attributing some knowledge to them because the generalists at least were experts. Therefore, we also asked children to rate how certain they were about their responses to determine if children were indeed more confident in their attributions of principles knowledge than their attributions of trivia knowledge.

3.1. Method

3.1.1. Participants

Participants were 32 6-year-olds ($M_{age} = 6.26$; $SD = 0.46$; 16 females), 32 8-year-olds ($M_{age} = 7.74$; $SD = 0.58$; 19 females), 33 10-year-olds ($M_{age} = 9.83$; $SD = 0.58$; 17 females), and 32 adults ($M_{age} = 24.20$; $SD = 7.68$; 18 females), recruited from the greater North Dallas area. The sample was predominately white and middle class.

3.1.2. Procedure

Like Experiment 1, the procedure consisted of two parts (i.e., training and testing) and was the same for both adult and child participants. It is important to note that immediately upon completing Experiment 2, the same group of participants completed Experiment 3.

3.1.2.1. Training. Training for Experiment 2 was similar to Experiment 1, with the addition of training on two scales: a 4-point star scale for attributing knowledge and a 3-point scale for describing the participants' levels of certainty.

Table 6
Experiment 2 items.

Domain	Knowledge type	
	Underlying principles	Specific trivia
Tapir	Why the tapir grows up to look exactly like its parents	Why the tapir was named after a monster in ancient Chinese stories
Pangolin	Why the pangolin can have only one baby at a time, while other animals can have a lot of babies at once	Why the pangolin is used as a villain in the Power Rangers cartoon
Capybara	Why two capybaras living in the same group are more likely to get the same sickness than ones that live in different groups	Why it is illegal to have a capybara as a pet in some states but not all states
Axolotl	Why the axolotl needs to eat in order to have enough energy to swim	Why the axolotl is used in several Japanese cartoons

After being asked to think of examples of experts, participants were introduced to the 4-point star scale that was created for assisting the participants in describing the amount of knowledge the experts may have (i.e., the knowledge attribution scale). This knowledge attribution scale consisted of a laminated strip of paper measuring 10.5'' wide by 4'' tall with a horizontal row of four circles with an increasing number of stars inside each circle, ranging from 0 stars for "no knowledge" (far left) up to a group of stars for "a lot of knowledge" (far right). Additionally, under each circle was a label indicating the amount of knowledge that it represented, starting with "no knowledge", followed by "a little knowledge," then "some knowledge," and ending with "a lot of knowledge." The 3-point Likert scale from Experiment 1 was expanded to this 4-point scale to allow for more variance between how participants could attribute knowledge to themselves and to the experts.

Upon being handed the scale, participants were told that sometimes different people can know about the same topic but have different amounts of knowledge about that topic. Then, they were instructed to think of a topic and of different people who might have knowledge about that topic at each level of the scale. If participants could not or would not think of an example, the following was presented. Participants were told that some people know about all the different kinds of medicines. Then, they were asked to indicate on the scale how much they thought doctors, nurses, moms and dads, and car mechanics knew about all the different kinds of medicines. Finally, participants were asked to indicate on the scale how much they thought that they themselves knew about that topic (e.g., all the different types of medicines) to prepare them to be able to answer questions about their own knowledge. The experimenter concluded by telling participants that they were going to be asked how much some people know about different topics and the participant could point to a place on the scale to say that the person knows nothing, a little, some, or a lot about each item in question.

After being trained on the knowledge attribution scale, participants were trained on a 3-point certainty scale that has been used in previous work with younger age groups (e.g. Woolley, Boerger, & Markman, 2004; Woolley & Van Reet, 2006). Participants were told that sometimes they might be more sure than others about their answers, so after each answer they would be asked to point to the picture that showed whether they felt "really sure", "a little sure", or "not so sure" about the answers they just gave.

3.1.2.2. Testing. The procedure for Experiment 2 was similar to the procedure for Experiment 1: participants were asked to attribute both underlying principles and specific trivia knowledge, independently. However, to address our hypothesis regarding the *familiarity* of the topics, the items were constructed so that each pair of items (one principles item and one trivia item)[9] referred to one of 4 unfamiliar animals[10] (see Table 6) and the picture book of experts only contained the four generalists from Experiment 1. Further, when reading each of the items, we presented participants with photographic images of the unfamiliar animal to which the item referred. See Table 6 for a list of items from Experiment 2.

Also noteworthy, instead of simply asking participants to attribute the item to the expert and then moving on to the next item (as was the case in Experiment 1),[11] we collected three data points for each item. For each item, participants were asked (1) "how much does the expert know about [the item]?" using the knowledge attribution scale, (2) "how *sure* are you that (s)he knows [that much] about [the item]?" using the certainty scale, and then (3) "how much do you know about [the item]?" using the knowledge attribution scale. Participants' responses on the knowledge attribution star scale were converted to a 4-point Likert scale where "knows nothing" answers were scored as 0, "knows a little" answers were scored as 1, "knows some" were scored as 2, and "knows a lot" answers were scored as 3. Participants' responses on the certainty scale were converted to a 3-point Likert scale where 'not so sure" answers were scored as 0, "a little sure" answers were scored as 1, and "really sure" answers were scored as 2.

3.2. Results and discussion

The primary goal of Experiment 2 was to examine why participants might have been attributing trivia knowledge to the generalists in Experiment 1. One theory was that participants may have thought that generalists would have

[9] Also like Experiment 1, whether participants were asked to attribute the underlying principles item first or the specific trivia item first was counterbalanced both between experts and between participants.

[10] This experiment focused only on the animal domain, given that there are many examples of unfamiliar animals that have been used in research with children (e.g., Corriveau et al., 2009; Grief, Kemler Nelson, Keil, & Gutierrez, 2006).

[11] It is important to keep in mind that participants in Experiment 1 would see the item again later in the study when attributing knowledge to the other type of expert.

some trivia knowledge because the topics chosen for each of the items (e.g., Persian cats, poodles) were familiar enough that it is likely for anyone (expert or not) to know some specific trivia associated with these topics. Thus, to investigate this, we were primarily concerned with comparing knowledge attributions for the generalist with knowledge attributions for the self.

We anticipated that participants would attribute much more underlying principles knowledge to the generalist than to themselves, given the expert status of the generalist and the likelihood of a generalists' expertise clustering by knowledge of underlying principles related to the discipline. However, there were two possibilities with regard to how participants might have attributed specific trivia knowledge. The first is that participants would still attribute more specific trivia to the generalists than to themselves, suggesting that participants expect that animal experts' expert status grants them privileged access to trivia knowledge (i.e., more knowledge than a layperson) about all kinds of animals, familiar or not. The second is that participants will attribute similar amounts of specific trivia to the generalists as to themselves, suggesting that participants do *not* expect animal experts to have more privileged access to trivia knowledge about these unfamiliar animals than the participants themselves.

To investigate this, we began by conducting a mixed-design ANOVA with age as a between-participants variable and source (generalist, self) and knowledge type as within-participants variables. The dependent variable was the average amount of knowledge attributed on the 4-point Likert scale (see Section 3.1.2.2). See Table 7 for significant effects from the ANOVA.

As with Experiment 1, there was a source by knowledge type interaction, but unlike Experiment 1 that interaction did not seem to vary between the age groups (no significant three way interaction between source, knowledge type, and age, $p = .53$). Thus, we first examine the source by knowledge type interaction to see how participants, collapsed across age, attributed the two knowledge types to the two source types. Then, we examine the existing developmental differences in participants' knowledge attributions.

3.2.1. Comparing knowledge attributions between the sources

As previously stated, the ANOVA revealed a source by knowledge type interaction such that the difference between knowledge attributed to the generalists and to the self was larger for principles knowledge ($MD = 1.39$, $SD = 0.84$, $d = 2.07$) than for trivia knowledge ($MD = 1.24$, $SD = 0.86$, $d = 1.79$). That said, the difference between the sources was significant for both types of knowledge (both $ps < .001$). See Fig. 2. Thus, given that participants attributed not only more principles knowledge but also more specific trivia knowledge about the unfamiliar animals to the generalists than to themselves, it seems most likely that participants expect that animal experts' expert status grants them privileged access to specific trivia knowledge (i.e., more knowledge than a layperson) about all kinds of animals, familiar or not.

Table 7
Significant main effects and interactions from Experiment 2.

Effect	F	p	η^2_p
Main effect: *Source*	373.65	$p < .001$	.749
Main effect: *Knowledge type*	85.49	$p < .001$	.406
Interaction: *Knowledge type* by *Age*	4.64	$p = .004$	.100
Interaction: *Source* by *Knowledge type*	5.07	$p = .026$	.039
Main effect: *Age*	5.00	$p = .003$	.107

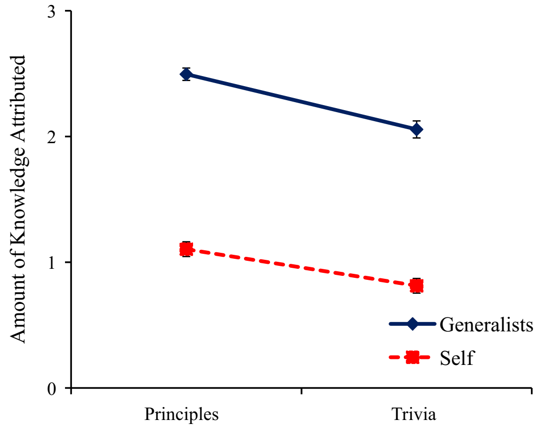

Fig. 2. Source by knowledge type interaction. Amount of specific trivia and underlying principles knowledge that participants attributed to generalists and to themselves.

3.2.2. Comparing knowledge attributions across development

A secondary goal of Experiment 2 was to examine developmental differences. Although the source by knowledge type interaction did not vary developmentally in this experiment (no significant source by knowledge type by age interaction), one factor that did change across development was the average *amount* of knowledge attributed (i.e., main effect of age, collapsed across the two source types and the two knowledge types). Bonferroni-corrected t-tests revealed that adults ($M = 1.38$, $SD = 0.45$) attributed significantly *less* knowledge overall than both 6-year-olds ($M = 1.79$, $SD = 0.48$, $p = .003$, $d = 0.90$) and 8-year-olds ($M = 1.73$, $SD = 0.49$, $p = .018$, $d = 0.76$).[12] However, this main effect of age should be viewed in light of the significant interaction of knowledge type by age (collapsed across source). Two simple-effects tests reveal that there are age differences in the attribution of *trivia* knowledge, $F(3,125) = 8.56$, $p < .001$, $\eta^2_p = .17$, but not for the attribution of *principles* knowledge, $F(3,125) = 1.56$, $p = .204$, $\eta^2_p = .04$. Follow-up Bonferroni-corrected t-tests reveal that 6-year-olds attributed more trivia knowledge than both 10-year-olds ($p = .024$, $d = 0.74$) and adults ($p < .001$, $d = 1.15$). Eight-year-olds, on the other hand, only attributed more trivia knowledge than adults ($p = .002$, $d = .96$).[13] See Fig. 3. This finding provides additional support for the theory from Experiment 1 that what is changing across development is

[12] Six- and 8-year-olds did not differ significantly from each other ($p = 1.000$), nor did they differ from 10-year-olds (both $ps > .50$). Moreover, adults and 10-year-olds did not differ from each other ($p = .41$).

[13] Six-and 8-year-old did not vary significantly from one another ($p = 1.000$), nor did 10-year-olds vary significantly from adults ($p = .58$).

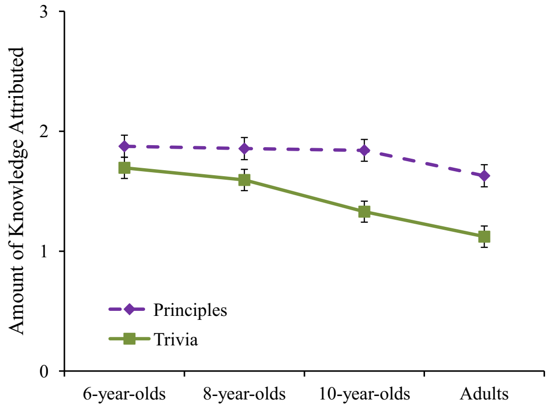

Fig. 3. Knowledge type by age interaction: the amount of principles and trivia knowledge that participants attributed across the age groups; collapsed across source (the generalist and the self).

the attribution of trivia knowledge. Like in Experiment 1, as participants get older, they are more likely to see specific trivia as specialized knowledge and are therefore likely to attribute less of it.

3.2.3. Comparing certainty evaluations across development

We also thought that participants may have been less certain when attributing specific trivia than underlying principles. To determine how children's certainty about their knowledge endorsements compared to those of adults, we conducted a mixed-design ANOVA, with age (6-, 8-, 10-year-olds, and adults) as a between-participants variable and knowledge type (underlying principles items, specific trivia items) as a within-participants variable. The ANOVA revealed that participants were indeed less certain about their responses to how much generalists know about specific trivia ($M = 1.29$ of 2, $SD = 0.05$) than how much they would know about underlying principles ($M = 1.50$ of 2, $SD = 0.04$), $F(1, 125) = 31.09$, $p < .001$, $\eta_p^2 = 0.20$, and this did not vary across development (i.e., no knowledge type by age interaction, $p = .139$). This provides an additional perspective on how participants are thinking about what the experts are likely to know, showing greater uncertainty across development in how much trivia a generalist is likely to know.

4. Experiment 3

In Experiment 1, participants attributed both underlying principles and specific trivia to the *specialists*; thus, it is unclear whether participants perceived any limitations to specialists' expertise. It is likely that participants in Experiment 1 attributed a lot of both types of knowledge to the specialists because the items referred to each specialist's specific topic of expertise (e.g., participants were asked to evaluate a Persian cat expert's knowledge about Persian cats). Thus, to truly understand how participants might perceive limitations to a specialist's expertise, participants must be asked to evaluate a specialist's knowledge of topics outside of their own topics of expertise. For example, would a Persian cat expert know why a dachshund was used as the mascot for the Summer Olympics in 1972? Persian cats and dachshunds are both animals, yet it seems unlikely as this trivia knowledge about dachshunds is not generalizable to the Persian cats. It seems more likely that a Persian cat expert would have knowledge of why two dachshunds that live in the same house are more likely to get the same sickness than two dachshunds that live in different houses. Although this knowledge item refers to a topic outside of the Persian cat expert's domain of expertise (i.e., dachshunds), the underlying principle of this knowledge item (i.e., disease transmission) applies not only to dachshunds but also to Persian cats and most other animals. Thus, Experiment 3 focused on determining whether participants expected specialists to have underlying principles knowledge (and not specific trivia knowledge) about topics slightly outside of (but related to) their own domains of expertise.

As Experiment 3 focuses on asking participants to evaluate specialists' knowledge about familiar topics of expertise (e.g., dogs, cats, birds), we felt that it was particularly important to account for whether participants felt that that the items might be knowable by non-experts (i.e., themselves). After all, if participants continued to attribute a high amount of knowledge to specialists outside of their own domains of expertise (particularly trivia knowledge), it might be because they assume that a lot of people, expert or not, may have knowledge of these items. Thus, like with Experiment 2, we asked participants to also evaluate how much they thought that they knew about the items in question. However, unlike Experiment 2, we did not have specific *a priori* hypothesis about participants' certainty about their responses, so we did not include the certainty scale in Experiment 3.

4.1. Method

4.1.1. Participants

Participants were the same sample used in Experiment 2.

4.1.2. Procedure

Immediately upon completing Experiment 2, participants were introduced to the materials for Experiment 3. As Experiment 3 immediately followed Experiment 2 and the methods were similar, no further training was necessary. Thus, Experiment 3 consisted only of a testing phase. Also, like the previous two experiments, the procedure for Experiment 3 was the same for both adults and children.

4.1.2.1. Testing. The procedure for Experiment 3 was similar to Experiment 2: participants were asked to attribute underlying principles and specific trivia items,[14] independently, to experts and to themselves using the knowledge attribution scale (see Section 3.1.2.2). However, participants were not asked to rate their levels of certainty (as we had no specific hypotheses for Experiment 3 related to certainty and we had limited time to work with each participant), and where the items in Experiment 2 referenced unfamiliar animals, the items in Experiment 3 referenced familiar ones

[14] As in the previous two experiments, the order of the underlying principles and specific trivia items were counterbalanced between expert and animal pairs as well as between participants.

Table 8
Experiment 3 items.

Basic-level category	Knowledge type		Specialist asked in *Near* condition	Specialist asked in *Far* condition
	Underlying principles	Specific trivia		
Dog	Why two dachshunds that live in the same house are more likely to get the same sickness than two dachshunds that live in different houses	Why the dachshund was used as the mascot of the summer Olympics in 1972	Poodle expert	Persian cat expert
Cat	Why baby calico cats can have blue eyes when both of their parents have brown eyes	Why calico cats are considered good luck in both America and Japan	Persian cat expert	Poodle expert
Bird	Why flamingos need to eat in order to have enough energy	Why Flamingo was chosen as a name for a WWII airplane	Duck expert	Iguana expert
Lizard	Why baby geckos grow inside eggs when other baby animals grow inside their moms	Why Gecko was chosen as a band name for a group in Europe	Iguana expert	Duck expert

(see Table 8). Moreover, Experiment 3 focused on specialists as opposed to generalists.

The familiar items in Experiment 3 were similar to the familiar animal items and specialists used in Experiment 1 with a few changes. First, we replaced one of the bird specialists from Experiment 1 (the turkey expert) with a lizard specialist (an iguana expert). Second, we created a list of items referring to expertise about an additional series of animals: a dachshund, a calico cat, a flamingo, and a gecko. Like with Experiment 2, we used photographic images of these animals to show participants when reading each of the items. Which animal was introduced for which specialist was based upon the condition to which a participant was assigned. For the "near" condition, specialists were paired with animals that are under the same basic-level category (in a hierarchical taxonomy; e.g., bird, cat; Rosch et al., 1976) as the animal of their specialty (e.g., participants were asked to evaluate a duck expert's knowledge about another type of bird, a flamingo). For the "far" condition, specialists were paired with animals that were not in the same basic-level category as the animal of each specialist's expertise but for which the underlying principles items were still generalizable (e.g., participants were asked to evaluate a duck expert's knowledge about another egg-laying animal, a gecko). As there were four experts and two items per expert, participants answered a total of eight items for Experiment 3. See Table 8.

4.2. Results

The primary goal of Experiment 3 was to examine whether participants expected specialists in one area of expertise (e.g., Persian cat expert) to have underlying principles and/or specific trivia knowledge regarding a related topic (e.g., calico cats, dachshunds), and whether those expectations change across development. We had anticipated that the most sophisticated participants would expect specialists to have underlying principles knowledge of the related topics whether they were near the specialists own domain of expertise (i.e., same basic-level category; e.g., both cats) or further away (i.e., different basic-level categories; e.g., cat versus dog), as these knowledge items were created to be generalizable. In contrast, they would not expect specialists to have any more specific trivia knowledge than they themselves would, especially when asked about topics in a different basic-level category (e.g., asking about the Persian cat expert knowing dachshund trivia).

To examine these aims, we began by conducting a mixed-design ANOVA with age and condition (near versus far) as between-participants variables and source (specialists versus self) and knowledge type as within-participants variables. As with Experiment 2, the dependent variable was the amount of knowledge attributed on a scale of 0–3 (see Section 3.1.2.2). See Table 9 for significant main effects and interactions from the ANOVA.

As with Experiment 2, the interactions of interest (i.e., the source by knowledge type and the source by knowledge type by Condition) did not vary developmentally. Thus, we begin by following-up on the interactions of interest and then we examine other effects that did vary across development.

4.2.1. Comparing knowledge attributions across source and condition

The primary goal of Experiment 3 was to determine whether participants would expect specialists to have

Table 9
Significant main effects and interactions from Experiment 3.

Effect	F	p	η_p^2
Interaction: *Source* by *Knowledge type* by *Condition*	9.17	$p = .003$	.070
Main effect: *Source*	61.44	$p < .001$	.337
Interaction: *Source* by *Age*	6.59	$p < .001$	.140
Main effect: *Knowledge type*	276.40	$p < .001$	.696
Interaction: *Knowledge type* by *Age*	40.42	$p < .001$	.501
Interaction: *Source* by *Knowledge type*	16.46	$p < .001$	.120
Main effect: *Condition*	5.29	$p = .031$	.038
Interaction effect: *Condition* by *Source*	13.33	$p < .001$	.099
Main effect: *Age*	11.70	$p < .001$	.225

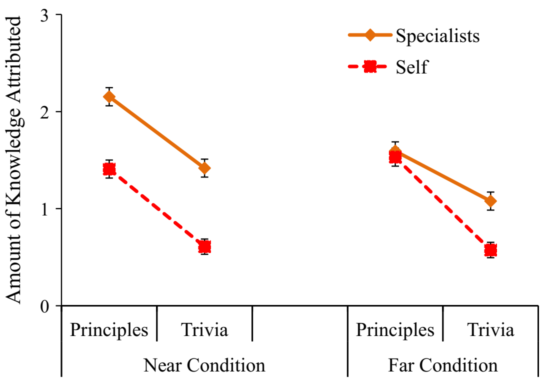

Fig. 4. Source type by knowledge type by condition interaction. Amount of specific trivia and underlying principles knowledge that participants attributed to generalists and to themselves.

more underlying principles knowledge than themselves but similar amounts of specific trivia knowledge as themselves about topics outside of the specialists own domains of expertise, and whether this changed based on the distance between the topics of expertise (near versus far conditions). As these effects did not vary by age, we present these results collapsed across that variable.

Like with Experiments 1 and 2, there was a significant source by knowledge type interaction, but this should be viewed in light of the significant three-way interaction of source type, knowledge type, and condition. Bonferroni-corrected t-tests reveal that, for the *near condition*, participants rated specialists as having more knowledge than themselves about both specific trivia, $t(64) = 7.41$, $p < .001$, $d = .92$, and underlying principles, $t(64) = 7.17$, $p < .001$, $d = .89$. However, in the far condition, participants rated specialists as having more knowledge than themselves only about specific trivia, $t(63) = 4.57$, $p < .001$, $d = 0.57$, and not about underlying principles, $t(63) = 0.517$, $p = .607$, $d = .06$. See Fig. 4. In other words, for example, participants expected poodle experts to know more principles than themselves about other dogs, but not necessarily more principles than themselves about other animals like cats.

This result is particularly interesting as we expected the reverse to happen: we had anticipated that participants, particularly in the far condition, would attribute similar amounts of specific trivia knowledge to the specialists as they did to themselves and a lot more principles knowledge to the specialists than to themselves. One reason for this is a point that we discussed with regard to the results of Experiment 2: when the information gets more difficult to know, such as is the case with trivia knowledge, participants may be more inclined to attribute this knowledge to experts, even if the item is out of scope of the expert's knowledge domain. Thus, participants may never assume that they have the same amount of trivia knowledge as an expert.

It is also noteworthy that Bonferroni-corrected t-tests reveal that what changes significantly between the near condition and the far one is the attribution of principles knowledge to the specialists ($p < .001$).[15] This is surprising because the underlying principles knowledge should be perceived as equally generalizable between the two conditions; for example, a Persian cat expert should be equally likely to know about the genetics of eye color and disease transmission as both underlying principles are applicable to Persian cats as well as the topics to which they referred (in this case calico cats and dachshunds). Thus, in this case, it seems like the distance between the topics (how related they are to one another) plays a much larger role than whether the knowledge is generalizable from one expert to another. We discuss this more in the Open Questions section of the General Discussion (Section 5.4).

4.2.2. Comparing knowledge attributions across development

A secondary goal of Experiment 3 was to examine what effects vary developmentally. Although the source by knowledge type and source by knowledge type by condition interactions did not vary by age, there were three results that demonstrated developmental effects: a main effect of age, a source by age interaction, and a knowledge type by age interaction. Bonferroni-corrected t-tests reveal, for the main effect of age, that 6-year-olds ($M = 2.20$, $SD = .71$) attributed more knowledge than 10-year-olds ($M = 1.18$; $SD = .84$; $p < .001$, $d = 1.33$) and adults ($M = 1.18$, $SD = .46$; $p < .001$, $d = 1.73$). Similarly, 8-year-olds ($M = 1.70$; $SD = .87$) attributed more knowledge than 10-year-olds ($p = .033$, $d = 0.62$) and adults ($p = .034$, $d = 0.76$). Furthermore, 6-year-olds trended towards attributing more knowledge than 8-year-olds ($p = .07$, $d = .64$), but 10-year-olds and adults did not differ significantly from one another ($p = 1.000$).

Source by age. To follow up on the source by age interaction, we conducted two simple-effects, one-way ANOVAs (correcting for multiple comparisons) to determine whether there were developmental differences in knowledge attributions (collapsed across knowledge type) to the specialist and to the self. We found that there were developmental differences for the amount of knowledge attributed to the specialists, $F(3,125) = 14.036$, $p < .001$, but not to the self, $F(3,125) = 1.903$, $p = .530$. Following up on the knowledge attributions to the specialist, Bonferroni-corrected t-tests revealed that 6-year-olds ($M = 2.20$, $SD = 0.71$) attributed significantly more knowledge than 10-year-olds ($M = 1.18$, $SD = 0.84$; $p < .001$, $d = 1.324$) and adults ($M = 1.18$, $SD = 0.45$; $p < .001$, $d = 1.734$), and 8-year-olds ($M = 1.70$, $SD = 0.87$) attributed significantly more knowledge than adults ($p = .024$, $d = 0.76$). No other age groups varied from one another. See Fig. 5.

Knowledge type by age. To follow up on the knowledge type by age interaction, we conducted two simple-effects ANOVAs (correcting for multiple comparisons) to determine whether there were developmental differences in attributions of underlying principles and specific trivia knowledge (collapsed across attributions made to the specialist and to the self). We found that there were developmental differences for attributions of specific

[15] For principles and trivia attributions for the self, both $ps > 0.35$; trivia attributions for the expert were extremely close to being significantly different between conditions, $p = .053$.

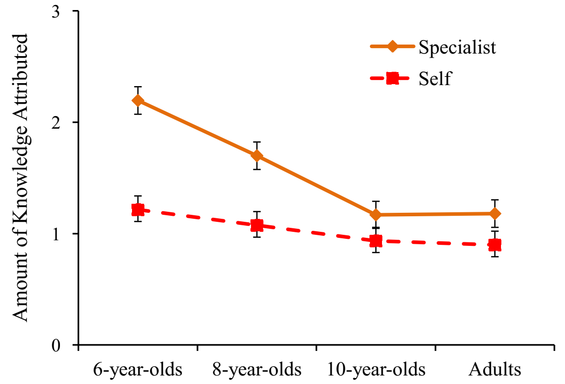

Fig. 5. Source by age interaction: the amount of knowledge (collapsed across principles and trivia) that participants attributed across the age groups, collapsed across condition.

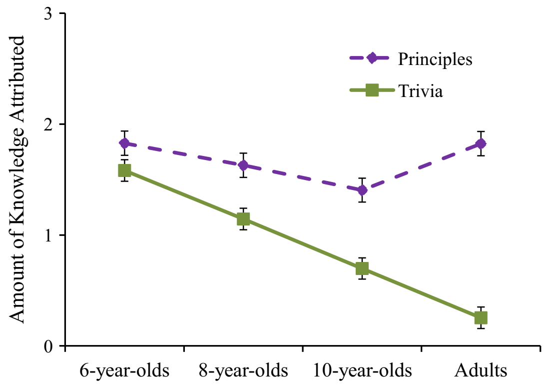

Fig. 6. Knowledge type by age interaction: the amount of principles and trivia knowledge that participants attributed across the age groups; collapsed across source (the specialist and the self) and condition.

trivia, $F(3,125) = 34.141$, $p < .001$, but not for attributions of principles knowledge, $F(3,125) = 3.797$, $p = .10$. Following up on the specific trivia attributions, Bonferroni-corrected t-tests revealed that each age group differed significantly from one another (all $ps < .03$, all $ds > .70$), such that 6-year-olds attributed the most trivia knowledge and adults attributed the least. See Fig. 6.

5. General discussion

Three experiments were conducted to examine children's and adults' expectations regarding the boundaries of expertise—how an expert's knowledge is perceived to be limited and how these perceptions change across development. Although prior research has demonstrated that children can sometimes tell which of two facts a specialist or a generalist is likely to know, this work tells us little about where children might see limitations to each of these experts' knowledge. The current work fills this gap, providing participants the opportunity to evaluate whether experts who vary in the breadth of their expertise (i.e., generalists and specialists) have knowledge of two types of facts that vary in how in-depth they are (i.e., underlying principles and specific trivia). Thus, the current work contributes to the literature by examining developmental changes in how children perceive *what kinds* of knowledge and *how much* of that knowledge these different types of experts should have.

5.1. Recognizing differences between generalists and specialists

One aim of the current study was to determine by what age children recognize that *specialists* are likely to have different types and amounts of knowledge than *generalists*. Results from Experiment 1 found that by age 8, children endorsed specialists as having more knowledge than generalists about *underlying principles*. By age 10, children endorsed specialists as having more knowledge than generalists about *specific trivia*. Overall, then, it seems that children expect specialists to know more than generalists. One reason for this belief may be that children recognize that the domains of expertise for specialists encompass a narrower range of topics than generalists, and thus assume that it is more plausible for specialists to know specific trivia about all the topics in their narrow domain than for generalists to know about all the topics in their broader one.

An alternative explanation, however, relates to the fact that the stimuli used in Experiment 1 involved the specialists' exact area of expertise (e.g., children were asked if a poodle expert and an animal expert would know about how *poodles* might get sick) and not the general category label used to describe the generalists' area of expertise (e.g., children were not asked if a poodle expert and an animal expert would know about how *animals* might get sick). It is possible that children may have granted more knowledge to the specialists than to the generalists because they were simply matching the expertise label to the topic label used in the question. That said, we do not believe this is the primary explanation for children's performance, as children showed sensitivity to the type of knowledge being asked about (i.e., general principle versus specific trivia) as well as whether some types of knowledge are even plausible to have (i.e., impossible knowledge item).

Moreover, it is possible that children could have interpreted the absence of information about an animal expert's poodle knowledge as meaningful. Specifically, children might have expected that if an animal expert had poodle knowledge, we would have specifically stated so. However, this is also not likely the case as children attributed a lot of underlying principles knowledge and even some specific trivia knowledge about the subordinate topics (e.g., Persian cats, Poodles) to the animal experts in Experiment 1; they just attributed less of this knowledge to generalists than to specialists. Future research can aim to examine in what cases people may perceive generalists to know more than specialists.

5.2. Evaluating generalists' and specialists' knowledge

In addition to comparing how children and adults think of generalists versus specialists, we also were interested in examining how children's expectations of what each expert (generalist and specialist) is likely to know might change over development.

Regarding *generalists*, in both Experiments 1 and 2, children by age 8 thought generalists were likely to have more underlying principles knowledge than specific trivia knowledge, with the greatest differences being perceived by adults. As previously stated (see Sections 2.2.1 and 3.2.2), this difference was driven by their responses regarding specific trivia. This result demonstrates that over the course of development children begin to understand that a generalist's knowledge is in fact likely to be limited.

Interestingly, even though participants were less certain about their attributions of specific trivia knowledge, participants continued to attribute specific trivia to the generalists even when the knowledge referred to unfamiliar topics (Experiment 2). In fact, participants attributed significantly more of both types of knowledge to generalists than they did to themselves, suggesting that participants expect animal experts to have privileged access to specific trivia knowledge (i.e., more knowledge than a layperson) about both familiar and unfamiliar animals.

Regarding *specialists*, in both Experiments 1 and 3, children and adults thought specialists were likely to know more about underlying principles than about specific trivia. But overall, children and adults believed that specialists would still have a lot of both kinds of knowledge, at least when the knowledge was about their own domains of expertise (e.g., in Experiment 1). This finding expands on past research in an important way. Past research showed that when children are asked whether a specialist would be more likely to know underlying principles knowledge or specific trivia knowledge, they respond at chance levels. Although one possible explanation for this finding was that children did not have any idea what a specialist was likely to know (e.g., Keil et al., 2008), the current research supports that it is more likely that children (and adults) believe that specialists know a lot about both.

Although children and adults thought that specialists would have a lot of knowledge about their own domains of expertise, this was not the case when asked about other, related domains of expertise. The results from Experiment 3 suggested that as children get older, they are less likely to think that specialists know both underlying principles and specific trivia about other, related topics—particularly when those topics are in a different basic-level category (e.g., less likely to think Persian cat experts know about a specific type of dog). Presumably, older children and adults are attributing less knowledge overall to specialists because these participants are thinking more critically about what each expert is likely to know based on that expert's topic of expertise. Younger children, on the other hand, are attributing a lot of overall knowledge to specialists because they may be more focused on the fact that the informants are called "experts" and are not taking into consideration the topic of that specialist's expertise or how that specialist's knowledge might be limited.

5.3. What is developing in understanding expertise?

These three experiments suggest that, at least superficially, what is developing across the age groups is the understanding that having expertise does not guarantee having specialized, specific trivia knowledge. Indeed, no developmental differences were seen in how children attributed underlying principles to experts across the experiments. However, younger children attributed much more *specific trivia* than older children and adults did. In Experiment 1, younger children thought that *generalists* would know more specific trivia than older children and adults did, though the amount of trivia attributed was constant across the age groups for *specialists*. Then, in both Experiments 2 and 3, younger children attributed more specific trivia knowledge overall than older children than adults.

This may relate to findings by prior research showing that even though younger children are capable of clustering knowledge by discipline (Keil et al., 2008), they more naturally prefer to cluster by topic, not shifting to holding a preference to cluster by discipline until age 10 (Danovitch & Keil, 2004). Our research, however, has taken this result a step further by demonstrating that participants across the ages seem to expect both generalists and specialists to have a cluster of knowledge based on underlying principles associated with their discipline. In addition, the younger age groups expect these experts also to have a cluster of knowledge based on topic. As children get older, they begin to recognize that experts might be limited insofar as they will not have all knowledge that can be categorized by topic with their domain of expertise.

Moreover, it is possible that our findings could explain *why* children seemed to shift away from preferring to cluster by topic between ages 8 and 10 in prior work: children may start to doubt that experts can have very specific knowledge that seems to be relevant in topic label only. Thus, between 8 and 10, children are likely beginning to integrate (a) knowledge of what is relevant to someone's expertise, (b) by what means that knowledge is relevant (e.g., topic, discipline), and (c) even if it is relevant, whether it makes sense that someone could and would have that knowledge.

However, it is an open question exactly what mechanisms are driving children's developing understanding of expertise. One likely possibility is children's conceptual understanding of categories. After all, it seems intuitively correct that children who are better at recognizing the different ways in which objects can be related to one another (e.g., defining features, causal relationships) will also be better at recognizing the different ways in which knowledge can cluster together (e.g., topic, underlying principles). Recent work by Danovitch and Noles (2014) supports this possibility, finding that children's ability to categorize objects (e.g., saying that an eagle "goes with" a chicken versus the other two options—grass and an elevator) was predictive of their understanding of what an expert is likely to know (e.g., an eagle expert knows about other birds and animals). Moreover, our experiments were designed in such a way that children were asked to make assumptions about experts' knowledge based upon category-like labels of expertise (consistent with prior research, e.g., Keil et al., 2008; Lutz & Keil, 2002) as opposed to lengthy descriptions of what experts' knowledge encompasses. Still, experts in real life are more often referenced by labels (e.g., doctors, car mechanics, psychologists) than by lengthy descriptions of what they are likely to know. Future studies should continue investigate how children's developing conceptual understanding of categories influences their developing understanding of expertise.

It is important to consider, though, what other mechanisms may have been driving children's responses besides epistemic inferences about experts' knowledge. For example, children's responses may have been affected by the context of the experiment (i.e., the implicit and/or explicit comparisons participants may make between potential sources of information). For example, recent research by Shenouda and Danovitch (2013) found that children attribute knowledge differently depending on what experts were available. In the study, when children were given a choice to attribute cat expert to a dog expert or to a person without dog expertise, children chose to attribute the knowledge to the non-expert. However, when children were given a choice between a dog expert and a car expert, they attributed the cat knowledge to the dog expert. In the current set of experiments, this particular type of explicit comparison was not likely a factor as the design aimed at procuring absolute attributions of knowledge, as opposed to relative ones. That said, research in behavioral economics suggests that people rarely rate things in absolute terms; instead, they focus on the relative advantage of one or another (e.g., see Ariely, 2009). Thus, even though we did not ask children to compare the sources, they may have been implicitly doing so. Future research should aim to investigate how pairing sources (both explicitly and implicitly) may lead to changes in how knowledge is attributed.

Related to this, context is also important to consider as it can affect determinations of who the *best* source for information would be, especially if that source is unavailable to us (not included in the explicit or implicit comparison). Thus, we must make do with sorting between viable options. For example, if someone has a question about how to train their dog, the best person to ask, arguably, would be the famous dog-whisperer Cesar Millan. That said, Cesar Millan is not going to be the person who is most accessible. Therefore, one would need to choose between a few, more accessible options such as their veterinarian or a more local pet trainer. Furthermore, one's choice between their veterinarian and a local pet trainer may still be influenced by factors other than who has the most relevant expertise, such as location, cost, emotional valence (e.g., Boseovski & Thurman, 2013), and person-specific characteristics (e.g., who is nicer, more honest; e.g., Landrum et al., 2013; Lane, Wellman, & Gelman, 2013). Thus, there are many factors that influence how much knowledge someone is perceived as having. Although research has examined how some of these factors influence evaluations of trust (for a review see Mills, 2013), future research should aim to investigate how these factors also may influence evaluations of knowledge.

5.4. Implications and conclusions

An important challenge in development involves learning to attend to cues that are relevant to the likely accuracy of an informant rather than blindly accepting whatever someone says. One of these cues is the source's expertise. The current research demonstrates that even adults have difficulty determining when a source described as an expert is likely to know certain types of information, particularly when that information seems relevant to the expert's domain of expertise but is out of scope. It is important for future research to determine how to help adults and children better evaluate another person's putative expertise in order to assist them in finding and trusting the most accurate information. For instance, children who can appropriately evaluate a source's expertise may be more skeptical of persuasive messages from advertisers—messages that, if accepted blindly, can lead to risky behaviors such as drinking (Nash, Pine, & Messer, 2009) and smoking (Andrews, Netemeyer, Burton, Moberg, & Christiansen, 2004). Finally, children who develop the skills necessary to critically evaluate sources of information are likely to become adults who can do so, which is essential to ensure that they make informed and accurate decisions that could affect themselves and their children.

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