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How children use accuracy information to infer informant intentions and to make reward decisions

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ABSTRACT

The ability to assess the value of the information one receives and the intentions of the source of that information can be used to establish cooperative relationships and to identify cooperative partners. Across two experiments, 4- to 8-year-old children (N = 204) received a note with correct, incorrect, or no information that affected their efforts on a search task. Children were told that all informants had played the game before and knew the location of the hidden reward. In the no information condition, children were told that the informant needed to leave before finishing the note and, thus, was not intentionally uninformative. Children rated the note with correct information as more helpful than the note with no information; incorrect information was rated least helpful. When asked about the informant's intentions, children attributed positive intentions when the information was correct and when they received unhelpful information but knew the informant was not intentionally uninformative. Children attributed less positive intentions to the informant when they received incorrect information. When given the chance to reward the informant, children rewarded the informant who provided correct information and no information equally; the informant who provided incorrect information received fewer rewards. Combined, these results suggest that young children assume that informants have positive intentions even when they provide no useful information. However, when the information provided is clearly inaccurate, children infer more negative intentions and reward those

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informants at lower rates. These results suggest that children tend to reward informants more based on their presumed intentions, placing less weight on the value of the information they provide.

Introduction

Information is an essential resource that humans acquire and transmit across generations (Boyd & Richerson, 1985; Tomasello, 1999). It is valuable in part because it can improve decision making (Allen, 1990). In fact, among adults, information that is important for job success is highly valued and shared selectively (Kamakau, 1976; Palmer, 1991). Accurate information saves time and effort and, in some cases, can ensure survival. Inaccurate information can be costly to the receiver and can be a sign of negative intentions or ineptitude on the part of the informant. Thus, tracking information quality and agents' communicative intentions is valuable because it can be used to establish cooperative relationships and to identify cooperative partners (Alexander, 1987; Brown & Moore, 2000; Dunfield, Kuhlmeier, & Murphy, 2013; Vaish, Carpenter, & Tomasello, 2010). However, little is known about when and how children use the quality of the information they receive to make inferences about cooperative partners.

A primary way in which we evaluate information is by judging the helpfulness of the information we have been given. For example, when asking for information about the best place to buy a local item in a foreign city, adults might be inclined to trust the information provided by a source who is likely to be knowledgeable and well intentioned—a local guide. Taking the guide's advice, the traveler would learn whether the information was accurate only after using the information and going to the recommended store. This outcome, perhaps finding that the store is a tourist trap with very high prices, is then likely to influence the traveler's perception of that informant's intentions—"What a helpful guide!" versus "I can't believe he told us to go there! He must be getting paid by that store!" Such assessments of the informant's intentions might in turn dictate future actions toward that informant such as engaging the informant's services again and recommending them to others or avoiding the informant and steering others away.

In this study, we examined preschool and elementary school children's ability to evaluate and reciprocate toward informants on the basis of the information they provide. Specifically, we asked the following three questions. First, when are children capable of evaluating the accuracy of information based on their use of it? Second, what inferences do children draw about the informant's intentions based on the accuracy of the information? Third, how does this affect subsequent cooperation with the informant?

To understand how children evaluate information in the context of cooperation, using the information provided should carry a benefit or cost. We know from prior work that children can evaluate information using diverse cues. To determine whether information is reliable, they can use information about their informant (the informant's prior accuracy, traits, accent, etc.), their prior knowledge and perceptions, and their intuitions about what makes a good explanation (e.g., Harris, Koenig, Corriveau, & Jaswal, 2018; Lombrozo, 2016). However, prior work has not focused on children's evaluation of information in contexts where the information they have been given alters the amount of effort that children need to expend to complete a task. Thus, we developed a novel effortful task to make the information provided valuable or costly.

Once children determine the accuracy of the information they have been provided, they can infer the intentions of the informant. Existing research on the connection between information accuracy and informant intentions has revealed a complex relationship. By about 5 years of age, children can use information about an informant's past accuracy and prior intentions to make decisions about whose information to endorse (e.g., Birch, Vauthier, & Bloom, 2008; Couillard & Woodward, 1999; Gillis & Nilsen, 2013; Jaswal, Croft, Setia, & Cole, 2010; Koenig & Harris, 2005; Landrum, Mills, &

Johnston, 2013; Landrum, Pflaum, & Mills, 2016; Liu, Vanderbilt, & Heyman, 2013; Mascaro & Sperber, 2009; Ronfard & Lane, 2018; Shafto, Eaves, Navarro, & Perfors, 2012). Indeed, by 3 years of age, children excuse an informant's past inaccuracies if such inaccuracies were unintentional because the informant had a false belief or lacked access to relevant information (Nurmsoo & Robinson, 2009a; Robinson & Nurmsoo, 2009; but see Nurmsoo & Robinson, 2009b). However, although children are attuned to informant intentions, a history of prior accuracy can outweigh an informant's negative intentions when children need to decide whether to trust an informant (Liu et al., 2013). Moreover, when preschoolers have only one informant to work with and cannot compare the accuracy provided by two informants, they continue to trust an inaccurate or uninformative informant (Jaswal et al., 2010; Vanderbilt, Heyman, & Liu, 2014; Kim, Paulus, and Kalish, 2017). This suggests that children modulate their inferences about informant intention, or override them, based on the context. Thus, it is unclear whether children will automatically assign negative intentions to an informant who provided bad and costly information.

Once children have evaluated the accuracy of the information and inferred the intentions of the informant, they can use either factor or both factors to determine how much they should reward the informant in return. If the information is accurate, children will likely conclude that the informant intended to be helpful and, thus, is deserving of rewards. However, if the information is inaccurate but the informant had positive intentions, the problem becomes more complicated. Children may give fewer rewards because the information was not helpful, or they may give a greater amount of rewards based on the informant's positive intentions. We hypothesized that children would make reward decisions based on their perception of the informant's intentions. We made this prediction because intentions matter to children in interactions that involve an exchange of goods. For example, 4-year-olds favor an actor who has been nice to others over an actor who has been mean to others (Kenward & Dahl, 2011), and children 5 years of age and older are more likely to accept unfair distributions of resources when the actor making the offer did not do so intentionally (i.e., the actor had no choice) (Sutter, 2007; Wittig, Jensen, & Tomasello, 2013).

To date, only one study has investigated the role of an informant's communicative intentions in children's reciprocal cooperation. Three-year-olds were asked to identify occluded pictures based on information provided, or not provided, by two puppets (Dunfield et al., 2013). One puppet was informative and provided correct information, whereas the other puppet refused—"I know! But I'm not telling." Across two experiments, the authors found that children identified the puppet that provided information (rather than refused) as helpful (rather than sneaky) and chose to provide this puppet with information and instrumental help in later trials. These results demonstrate that, by 3 years of age, children selectively reward an informant when the informant's communicative intentions are positive but not when they are negative (refusal to share information). However, in this study there was a confound between the informant's communicative intentions and the information provided. The informant either provided accurate information showing positive intentions or provided no information with explicitly negative intentions. The forced-choice design also limits what one can conclude about situations with single informants and, in fact, may overestimate young children's capacities. For example, research using a forced-choice design found that 3-year-old children are able to distinguish between circular and noncircular explanations (Corriveau and Kurkul, 2014; Mercier, Bernard, & Clément, 2014), whereas research using a single informant found that it is not until children are 8 years old that they independently rate circular explanations lower than noncircular explanations (Mills, Danovitch, Rowles, & Campbell, 2017). As a result, it is currently unclear how children might reward an individual informant who willingly provided information but whose information turned out to be inaccurate.

To answer these questions, we provided children with information from a single informant that could be used in a search task and varied the accuracy of the information. Children were told that they would search a dollhouse for a special sticker. Before beginning their search, children received a note containing information about the location of the sticker, ostensibly from another child who had played the game earlier. Participants were told that the other child had put the sticker in the dollhouse and then wrote the note for them. The note said, "The sticker is here," circling a location on a photo of the dollhouse. This procedure established that the informant was knowledgeable about the location of the sticker and that the informant had provided the information willingly.

The information provided by the informant was either correct (identifying the actual location of the sticker in the dollhouse), incorrect (identifying a different location [Study 1]), or uninformative (a blank note with no information [Study 2]). Thus, the receipt of incorrect or no information would cost children time and effort relative to the receipt of correct information. Children were then asked to assess the helpfulness of the information they received and the intention of the informant (to help or to deceive). This allowed us to answer our first two questions, namely (a) whether children can evaluate the accuracy of the information based on their use of it and (b) how children use accuracy information to make inferences about informant intentions. Children were then given the opportunity to reward the informant with material resources using a modified dictator game. Such dictator games have been used extensively with this age range as a measure of altruism because they are costly to the child and allow children to vary the amount the reward they can give rather than simply rewarding or not in an all-or-nothing manner (Benenson, Pascoe & Radmore, 2007; Blake & Rand, 2010; Fehr, Bernhard, & Rockenbach, 2008; Smith, Blake, & Harris, 2013). This allowed us to answer our third question, namely (c) how children's experience with an inaccurate informant shapes their subsequent cooperation with that informant.

We tested children between 4 and 8 years of age because 4-year-olds can track the prior accuracy of informants (e.g., Pasquini, Corriveau, Koenig, & Harris, 2007; Ronfard & Lane, 2018) and are beginning to use intent information when deciding whether to trust the information they have been given (Mascaro & Sperber, 2009). Furthermore, by 8 years of age, children tend to reach a ceiling of giving half of their resources to a peer in dictator games (Smith et al., 2013), suggesting that the 4- to 8-year age range should capture variation in giving as a function of our manipulation.

Experiment 1

Method

Participants

A total of 80 children (46 girls) between 4 and 8 years of age were recruited at a local science museum in the northeastern United States: 40 younger children (M_{age} = 5 years 2 months, SD = 6 months, range = 4 years and 0 months to 6 years 0 months) and 40 older children (M_{age} = 7 - years 1 month, SD = 8 months, range = 6 years 1 month to 8 years 6 months). Children were randomly assigned to one of two conditions. In the *correct information* condition, children received correct information about the location of the sticker (n = 40, 25 girls; M_{age} = 6 years 1 month, SD = 1 year 3 months). In the *incorrect information* condition, children received incorrect information about the location of the sticker (n = 40, 21 girls; M_{age} = 6 years 2 months, SD = 1 year 1 month). An additional 20 children were recruited but excluded from the analyses for the following reasons: experimenter error (n = 4), failing a comprehension check (n = 8), saying they did not care about the stickers (n = 3), failing to follow the protocol (e.g., began searching for the hidden stickers before being given permission) (n = 3), failing to complete the experiment (n = 1), and parental interference (n = 1). These children were excluded prior to data analysis. However, our results are robust to the inclusion of these children. We were not permitted to gather demographic information, but the museum's surveys show that about 70% of the visitors are White and middle to high socioeconomic status.

Data availability

The data and syntax files that support the findings of this study are openly available at the Open Science Framework at https://osf.io/v8f7c/.

Materials

Children were shown a wooden dollhouse (9.7 × 10.8 × 16.0 in.), depicted in Fig. 1. This dollhouse contained 13 pieces of movable furniture. We conducted pilot testing (described in online supplementary material) to identify children's search preferences and to ensure that children could transfer the information from the photo "map" of the dollhouse to the actual dollhouse. The pilot study confirmed that children could use the map to find the sticker and led us to select the location behind the bath-

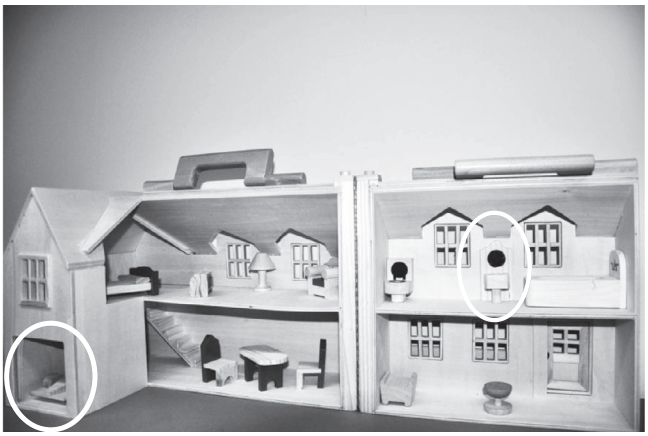

Fig. 1. Dollhouse used for search task. The sticker children needed to find was hidden behind the bathroom mirror (circled on the right). In the correct information condition, children received a note from another child telling them that the sticker was located behind the bathroom mirror (correct location). In the incorrect information condition, children received a note from another child telling them that the sticker was located in the garage (incorrect location circled on the bottom left).

room mirror furniture as the hiding place because it was the least often spontaneously searched location. The garage was selected as the incorrect location because it was farthest from the bathroom mirror and so starting the search there would impose costs of time and effort.

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jecp.2018.07.017.

Procedure

Children were randomly assigned to one of two conditions: correct information or incorrect information. They then participated in three phases: a *search task, judgments of the helpfulness of information and informant intentions,* and a *reward task.* Phases were presented in a fixed order and are described in more detail below. Two experimenters were present for each session.

Search task. Children were told that they were going to play a game that involved finding a sticker. They were shown a copy of the hidden sticker (a small metallic blue star) and were told that if they found it they would win a stick-on tattoo as a prize. They were then told that they had 20 s to find the star and that they could move the furniture pieces to find it. Once these instructions were given, all children were asked three questions: (a) "What do you have to find?"; (b) "If you find it, what do you get?"; and (c) "Can you move the pieces to find it?" All children were able to answer these questions.

Children were then given information about the location of the sticker from the informant, with the gender of the informant matching that of each child: "A girl [a female informant in the following example] that came earlier today played the game. After she was done playing the game, she put the sticker in the house and wrote this note for you." We chose to depict the informant as a peer to make the task more believable and because the reward phase of the experiment depended on giving stickers to a peer. Experimenter 1 (E1) then opened the note, which showed a photo of the dollhouse with one location circled. In both the correct information and incorrect information conditions, the note read, "The sticker is here." However, in the correct information condition the bathroom mirror was circled, whereas in the incorrect information condition the garage was circled. E1 pointed to the circled location while reading the note. E1 then told children that the game was about to start and counted down from "3". E2 started a stopwatch and recorded the number of locations children searched and the time it took children to find the sticker. Children could search until they found the sticker. Once children found the sticker, they were congratulated and allowed to pick their reward.

Thus, all children completed the task and "won" the tattoo regardless of how long it took them to find the hidden sticker. This helped to ensure that children's later donation to the informant would not be due to differences in children's emotional state (i.e., happy vs. disappointed). Moreover, because children's reasoning about information quality and informant characteristics is influenced by their experience with a task—that is, whether they failed or succeeded (Gillis & Nilsen, 2013; Palmquist, Jaswal, & Rutherford, 2016)—having children in both conditions succeed ensured that any differences between the two conditions could be tied back to the information children received.

Helpfulness of information and informant intention. Children were then asked three questions. First, children were asked about the helpfulness of the note they received: "Do you remember the note you got from the other girl at the beginning of the game? Was the note helpful/not helpful [counterbalanced]?" Based on their response, children were then asked to specify whether the note was either "very helpful or a little helpful" or "not helpful at all or a little not helpful." Both the initial dichotomous choice (helpful/not helpful) and the ordinal degree of helpfulness responses are analyzed in the Results section.

Children were then asked about the intention of their informant: "When the other girl made the note, do you think she was trying/not trying to help you [counterbalanced]?" Children were then asked to justify their answer: "Why do you think that she was trying/not trying [counterbalanced] to help you?" Finally, children were asked about the specific motives of their informant and were given three options: "When the girl made this note [pointing to note], do you think that she wanted you to win/made a mistake/wanted you to lose [counterbalanced]?"

Rewarding the informant. Children then participated in a modified dictator game using stickers (Blake & Rand, 2010). During the dictator game, the dollhouse and note from the child who "played the game earlier" remained open on the Table E1 presented children with four bowls of stickers. Each bowl contained a unique sticker design and 10 stickers with that design, and children were asked to select their favorite type of sticker. E1 then counted the 10 stickers that children selected and set them on the table. The stickers were placed in two parallel horizontal rows of 5 stickers. E1 gestured to the stickers on the table and told children that all of the stickers belonged to them. Children were told that they could keep all of the stickers for themselves or could give some to the child who wrote them the note at the beginning of the game (the recipient). For clarity, E1 referred to the recipient as "the girl who wrote you this note" and pointed to the open note on the table each time the recipient was mentioned during the dictator game. Children were told, "That girl isn't here anymore. She's coming back tomorrow. We'll make sure she likes the stickers, too." We told children that we would make sure that the person they gave the stickers to would like them to reinforce the idea that their informant was a real child and to make sure that children did not believe that the recipient valued the stickers less than they did.

E1 then presented children with two plain empty envelopes. E1 placed the first envelope on the table directly below the 10 stickers (closer to the children) and told children to put any stickers they wanted to keep for themselves inside that envelope. E1 then placed the second envelope on the table above the 10 stickers (farther from the children) and told children to put any stickers they wanted to give to the recipient inside that envelope. E1 then presented children with a three-sided "privacy box" and explained that, when the box was placed on the table (shielding children from view), no one would be able to see their decision. The reason for this privacy box and for the explanation we gave children was to ensure that children's donations were unaffected by their close proximity to the experimenter or their guardians.

Children were then asked comprehension questions to ensure that they understood the directions of the dictator game. First, children were asked who the stickers belonged to "right now." Second, children were asked where they should put any stickers they wanted to keep for themselves. Third, children were asked where they should put any stickers they wanted to give to the child who wrote them the note. Finally, children were asked whether anyone could see what they decided to do once the privacy box was placed on the table. If children answered any comprehension questions incorrectly, E1 repeated the instructions. Most children passed the comprehension checks the first time; children who did not pass after the questions were repeated were removed from the study.

Once E1 placed the privacy box on the table, children were told that they could begin. When children indicated that they were finished allocating the stickers, E1 lifted the privacy box and asked two final comprehension questions. First, children were asked which envelope belonged to them. Then, children were asked about the remaining envelope—"What do I do with this envelope?"—which was followed by "Who do I give it to" if children failed the second question. Correct responses referred to the child who had written the note; children who responded incorrectly were excluded from analyses.

Results

First, we evaluated the impact of testimony on children's search for the sticker to ensure that the condition manipulation worked as expected. Next, we examined children's assessments of the note's helpfulness and of the informant's intent. Then, we assessed whether children's assessment of the helpfulness of the information influenced their assessment of the informant's intent. Finally, we examined children's reward decisions as a function of the information they received. Preliminary analyses of children's search behaviors, evaluation of the information children received, attribution of intent, and reward decisions revealed no main effect of, or interactions with, gender. Thus, we report analyses without gender as a covariate.

Impact of testimony on children's search behaviors

To examine the impact of the information children received on their search behaviors, we created an index of their search effort by creating a composite measure out of the length of time children searched and the number of locations they searched. We created this index because these two measures of search effort were very highly correlated ($r = .70$, $p < .001$), and both of them measured information cost. To create this index, we standardized each variable. Then, we averaged them together ($\alpha = .82$). The resulting index measures, in standard deviation units, the effort (search time and number of searched locations) children expended when they searched for the hidden sticker. We examined the effort it took children to find the sticker using a 2×2 analysis of variance (ANOVA) with age (2: younger or older) and condition (2: correct information or incorrect information) as between-participants factors. This analysis revealed a significant effect of condition, $F(1, 76) = 41.49$, $p < .001$, $\eta^2 = .35$. Children in the incorrect information condition expended significantly more effort in looking for the sticker than children in the correct information condition ($M = .54$, $SD = .94$ vs. $M = -.54$, $SD = .49$). Age and the age by condition interaction were not significant. This analysis confirms that the receipt of incorrect information was costly to children, leading to wasted effort. Separate analyses of children's search time (incorrect information: $M = 37.21$ s, $SD = 35.98$; correct information: $M = 9.52$ s, $SD = 13.55$) and number of locations searched (incorrect information: $M = 7.13$, $SD = 3.64$; correct information: $M = 2.30$, $SD = 2.17$) support this conclusion (see supplementary material for details).

Children's judgments of the helpfulness of the information

Children in both conditions rated the helpfulness of the note they were given. Ratings of the helpfulness of the note were converted to numerical scores and treated as a continuous variable; "not helpful at all" was scored as 0, "a little not helpful" was scored as 1, "a little helpful" was scored as 2, and "very helpful" was scored as 3. Both older and younger children used the full scale (see supplementary material for histograms of the distribution of responses). We used a 2×2 ANOVA with age (2: younger or older) and condition (2: correct information or incorrect information) as between-participants factors to examine differences in children's helpfulness ratings across the two conditions. This analysis revealed a significant effect of condition, $F(1, 76) = 68.49$, $p < .001$, $\eta^2 = .41$, a significant effect of age, $F(1, 76) = 12.58$, $p < .001$, $\eta^2 = .08$, and a significant age by condition interaction, $F(1, 76) = 10.57$, $p = .002$, $\eta^2 = .06$. To unpack this interaction, we examined the simple effects of condition and age. As depicted in Fig. 2, both younger and older children rated the note in the correct information condition as more helpful than the note in the incorrect information condition, $F(1, 76) = 12.62$, $p < .001$ and $F(1, 76) = 66.43$, $p < .001$, respectively. Younger and older children rated the note in the correct information condition similarly, $F(1, 76) = 0.04$, $p = .84$. However, older children rated the note

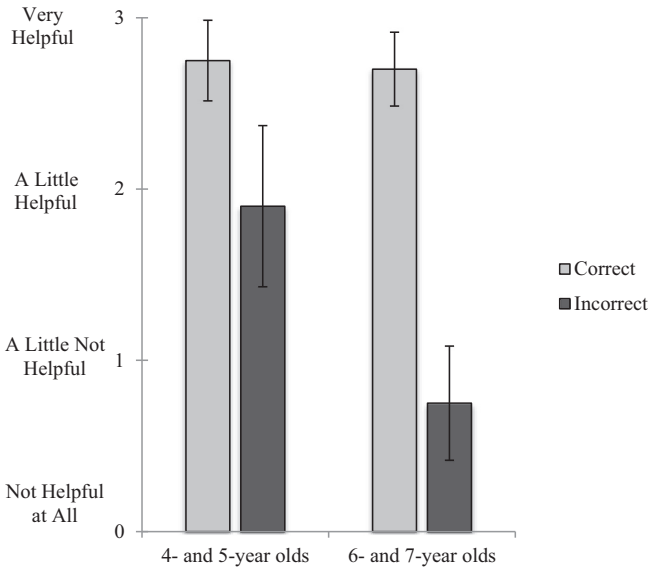

Fig. 2. Experiment 1: Mean helpfulness rating for the note children received in the correct information (gray) and incorrect information (black) conditions for younger and older children. Error bars represent 95% confidence intervals.

in the incorrect information condition as significantly less helpful than younger children, $F(1, 76) = 23.11$, $p < .001$. As further validation of these results, we reran this analysis using the initial dichotomous response of helpful or not helpful. The same pattern of results occurred (see supplementary material for details). Thus, in the incorrect information condition, older children tended to recognize that the note from the informant was not helpful, whereas younger children still rated this note as somewhat helpful, although less helpful than in the correct information condition. In sum, children at both ages explicitly recognized the helpfulness of the information that guided their search by differentiating between the correct and incorrect information.

Children's evaluation of the informant's intent

Children were asked whether they thought the informant was trying to help them (coded as 1) or not trying to help them (coded as 0). Children in both age groups stated that the informant was trying to help them more often in the correct information condition than in the incorrect information condition [younger: correct information condition, 90%; incorrect information condition, 60%; $\chi^2(1, N = 40) = 4.80$, $p = .03$; older: correct information condition, 100%; incorrect information condition, 45%; $\chi^2(1, N = 40) = 15.17$, $p < .001$]. Following the intent question, children were asked to choose one of three motives for the informant: whether the informant made a mistake, wanted them to win, or wanted them to lose. Note that 1 younger child and 1 older child did not answer this question. Younger children overwhelmingly said that the informant wanted them to win in both conditions (correct information: 90%; incorrect information: 79%), $\chi^2(2, N = 39) = 1.25$, $p = .54$. Older children also believed that the informant wanted them to win in the correct condition (95%) but showed more variation for the incorrect condition [wanted me to win, 35%; made a mistake, 40%; wanted me to lose, 25%; condition effects: $\chi^2(2, N = 39) = 15.27$, $p < .001$]. Combined, our analyses of children's responses to the intention and motivation questions suggest that both younger and older children had a more positive view of the intentions of the informant in the correct information condition than in the incorrect information condition but that older children made a sharper distinction between the intentions of these two informants. Indeed, 4- and 5-year-olds made this distinction only for the intention question but not for the motivation question.

Relation between judgments of helpfulness of information and attributions of intent

To assess whether children's perception of the helpfulness of the information they received influenced their attribution of intent to the informant, we conducted a series of logistic regression models using the –logit– command in Stata 14. We present the results of these regressions in Table 1 (results are shown in log odds). First, we regressed whether children thought the informant was trying to help them (coded as 1) rather than not trying to help them (coded as 0) on whether they received correct information rather than incorrect information (condition). Children were more likely to attribute positive intentions to the informant when they had received correct information rather than incorrect information (thereby replicating our previous analyses). Then, we regressed whether children thought the informant was trying to help them on their assessment of the helpfulness of the note they had received [scored from 0 ("not helpful at all") to 3 ("very helpful")], controlling for the condition to which children were assigned and their age (entered as a continuous variable, i.e., days/365). Children who rated the note as more helpful were more likely to attribute positive intentions to the informant. With the addition of children's helpfulness ratings to our model, the main effect of condition assignment on intent attribution was no longer statistically significant. The interaction between condition assignment and children's assessment of the note's helpfulness was not statistically significant (Table 1, Model 3). We reran this analysis using the initial dichotomous response of helpful or not helpful. The same pattern of results occurred (see supplementary material for details). Similar results were also obtained when we examined the relation between the motivations children assigned to the informant [i.e., positive motivations ("wanted me to win" or "made a mistake") vs. negative motivations ("wanted me to lose")] and their assessment of the note's helpfulness (see supplementary material for details).

Rewarding the informant

Children had an opportunity to reward the informant with stickers in a dictator game. We examined differences in children's giving using a 2 × 2 ANOVA with age (2: younger or older) and condition (2: correct information or incorrect information) as between-participants factors. This analysis revealed a significant effect of condition, $F(1, 76) = 16.19$, $p < .001$, $\eta^2 = .17$, and a significant effect of age, $F(1, 76) = 4.61$, $p = .04$, $\eta^2 = .05$. The interaction between age and condition was not significant, $F(1, 76) = 1.15$, $p = .29$. As depicted in Fig. 3, children in both age groups gave more stickers to the informant who provided correct information rather than incorrect information, and older children were more generous than younger children. Because the condition effect could reflect differences in the effort children expended in the two conditions (i.e., children worked harder to find the sticker in the incorrect information condition than in the correct information condition and, thus, felt that they had earned the right to hold on to more stickers; see Benozio & Diesendruck, 2015), we regressed the number of stickers children gave on the condition to which they were assigned, children's age (i.e., number of days/365), and the effort children expended in searching for the sticker (Table 2). The

Table 1
Logistic regression model (log odds) predicting children's attribution of positive intentions to the informant as a function of the condition to which they were assigned (Experiment 1: correct information vs. incorrect information), children's perception of the information's helpfulness, and children's age (continuous).

	Model 1	Model 2	Model 3
Correct information	2.84 (0.79)***	0.71 (1.01)	0.46 (2.84)
Helpfulness of note		1.91 (0.53)***	2.01 (1.17)***
Correct information × Helpfulness of note			−0.12 (1.30)
Age		0.48 (0.39)	0.48 (0.40)
Constant	0.10 (0.31)	−5.32 (2.87)	−5.24 (2.99)
Pseudo-R^2	.23	.47	.47
N	80	80	80
Model *df*	1	3	4
χ^2	20.87***	42.87***	42.88***

Note. Standard errors are in parentheses.
*** $p < .001$.

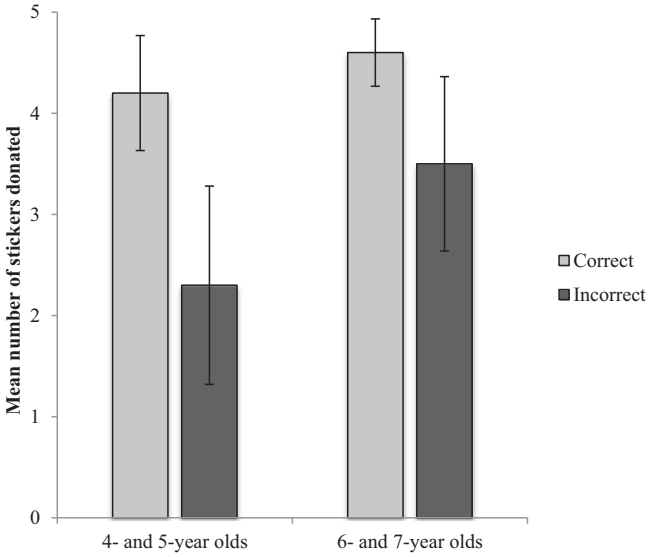

Fig. 3. Experiment 1: Mean number of stickers (out of 10) children donated to the informant in the dictator game in the correct information (gray) and incorrect information (black) conditions for younger and older children. Error bars represent 95% confidence intervals.

Table 2
Ordinary least squares regression model describing the relation between the number of stickers children donated, whether children received correct or incorrect information, children's age, and the effort children expended in searching for the stickers.

	Model 1
Correct information	1.63 (0.47)***
Age	0.29 (0.17)~
Search index	0.10 (0.26)
Constant	1.05 (1.07)
R^2	.20
N	80
Model sum of squares	54.48
Residual sum of squares	217.72
Model *df*	3
Residual *df*	76
F	6.34***

Note. Standard errors are in parentheses.
~ $p < .10$.
*** $p < .001$.

results of this analysis show that children's differential giving across conditions cannot be solely explained by differences in the effort children expended in the task.

Discussion

Experiment 1 assessed whether children (a) would evaluate the accuracy of information after using it to guide their search, (b) would draw inferences about the informant's intentions based on the accuracy of the information, and (c) would reward the informant in a manner consistent with the value of the information the informant provided and the informant's intentions. We found support for all three questions and gained some insight into how children reciprocate with single informants.

Children at all ages tested used the information provided by the informant to guide their search and correctly evaluated the information as more or less helpful. Older children were more likely to rate incorrect information as unhelpful, but even younger children rated incorrect information as less helpful than the correct information. Given the between-participants design and information from a single informant, it is impressive that even 4-year-olds were attuned to how helpful the information was.

In both age groups, children attributed positive intentions to the informant more often in the correct information condition than in the incorrect information condition. Moreover, regression models revealed that children who rated the information as more helpful were more likely to say that the informant was trying to help them. These results suggest that children were able to infer the intentions of the informant from the information the informant had provided. Furthermore, when children were given the chance to reward the informant, essentially paying the informant back, children at both ages gave less to the informant who had provided inaccurate information compared with the informant who had provided accurate information. However, given the consistency of children's ratings of the helpfulness of the information and the intentions of the informant, it is not clear which of these factors drove children's reward decisions.

To clarify how children were making reward decisions in this context, we added a new condition in which no information was provided even though the informant wanted to help. Specifically, children were told that the informant had started the note but had to leave before circling a location. The lack of information in the note should lead to a longer search and be rated as less helpful relative to the correct information condition. However, the unhelpful note should not be linked to the informant's intentions, which children should believe were positive. This design allowed us to disambiguate how children decide how to reward the informant. If children used the helpfulness of the note to reward the informant, then they should give the informant fewer stickers relative to the correct information condition. If children rewarded the informant based on the informant's presumed intentions, then they should give the informant more stickers than in the incorrect information condition.

In addition to the new condition, we also sought to clarify children's attributions of intent to the incorrect informant. Although children were more likely to attribute negative intentions to the incorrect informant, they seemed reluctant to do so. When provided with potential motivations for the informants, children rarely said that the incorrect informant wanted them to lose. However, the phrasing and format of the intention and motive questions may have pushed children toward more positive responses. For example, asking about informant helpfulness may have been confusing given that children were just asked about the helpfulness of the note. The motive question may also have provided options that children might not have considered, such as making a mistake, which 40% of the older children chose. To clarify the intention question, in Experiment 2 we asked children whether the informant wanted them to find the sticker or not. Given the change in our wording of the intent question, we did not include the motive question that also asked about wanting children to "win," that is, find the sticker.

Experiment 2

Method

Participants

A total of 124 children (67 girls) were recruited at a local science museum, the same population tested in Experiment 1: 61 younger children (M_{age} = 5 years, *SD* = 6 months, range = 4 years 1 month to 5 years 10 months) and 63 older children (M_{age} = 6 years 10 months, *SD* = 7 months, range = 5 years 11 months to 8 years). Children were randomly assigned to one of three conditions. In the *correct information* condition, children received correct information about the location of the sticker (*n* = 42, 22 girls; M_{age} = 6 years, *SD* = 1 year 1 month). In the *no information* condition, children received a blank note with no information about the location of the sticker (*n* = 41, 23 girls; M_{age} = 6 years, *SD* = 1 year 1 month). In the *incorrect information* condition, children received incorrect information about the location of the sticker (*n* = 41, 22 girls; M_{age} = 5 years 11 months, *SD* = 1 year 1 month). An additional

15 children were recruited but excluded from the analyses for the following reasons: experimenter error ($n = 4$), failing a comprehension check ($n = 10$), and saying they did not care about the stickers ($n = 1$). These children were excluded prior to data analysis, but our results are robust to the inclusion of these children.

Data availability

The data and syntax files that support the findings of this study are openly available at the Open Science Framework at https://osf.io/v8f7c/.

Materials

We used the same dollhouse from Experiment 1 and hid the sticker in the same location (i.e., behind the bathroom mirror).

Procedure

Children participated in three phases: a *search task, judgments of the helpfulness of information and informant intentions,* and a *reward task.* Following these three phases, some children completed an additional pilot task that was not analyzed. Phases were presented in a fixed order and are described in more detail below.

Search task. Children received the same instructions as in Experiment 1 with slight modifications to the phrasing to accommodate the new condition. Children were then told that E1 had a note for them from a child of the same gender who had played earlier. Children in all three conditions were told, "A girl [a female informant in the following example] that came earlier today played the game. After she played the game, she made this map for you to tell you where sticker is." Children were then randomly assigned to one of three conditions: correct information, no information, or incorrect information. In the correct information condition, E1 opened the note and said, "It says 'I circled where the sticker is,' and it looks like she circled the mirror." E1 then pointed to the circled location and said: "She had to leave after she was done writing this note." In the incorrect information condition, E1 said the same thing except that this time the note showed that the sticker was hidden in the garage. In the no information condition, E1 opened the note and said: "It says 'I circled where the sticker is,' and it looks like she didn't circle anything"; in contrast to the other two conditions, E1 then said, "She had to leave before she was done writing this note."

Helpfulness of information and informant intention. After completing the search and finding the hidden sticker, children were asked two questions. First, children were asked about the helpfulness of the note they received using the same prompt as in Experiment 1. Children were then asked about the intent of the informant: "Remember at the beginning of the game, I told you that a girl made this map for you after she played the game? When the other girl made this map for you, do you think that she did not want you to find the sticker/that she wanted you to find the sticker [counterbalanced]?" Note that we reworded our intent question from Experiment 1 so that it did not use the word "help."

Rewarding the informant. Children were then given the opportunity to reward the informant using the same modified dictator game task from Experiment 1.

Results

First, we evaluated whether the testimony children received influenced their search for the sticker, their evaluation of the information's helpfulness, and their evaluation of the informant's intentions. Then, we analyzed whether children's assessment of the information children received influenced their reasoning about the informant's intent. Finally, we investigated whether children differentially rewarded the informant based on the information they received. Preliminary analyses revealed a significant main effect of gender for children's reward decisions only. Thus, we included gender only in those analyses.

Impact of testimony on children's search behaviors

To examine the impact of the information children received on their search behaviors, we created the same search index as in Experiment 1. We standardized search time and the number of locations children searched and averaged them together ($\alpha = .81$). We examined the effort it took children to find the sticker using a 2 × 3 ANOVA with age (2: younger or older) and condition (3: correct information, no information, or incorrect information) as between-participants factors. This analysis revealed a significant effect of condition, $F(2, 118) = 16.08$, $p < .001$, $\eta^2 = .21$. Children expended less effort in looking for stickers in the correct information condition ($M = -.57$, $SD = .78$) than in the no information condition ($M = .19$, $SD = .86$), $F(1, 118) = 18.31$, $p < .001$, and in the incorrect information condition ($M = .39$, $SD = .84$), $F(1, 118) = 28.81$, $p < .001$, but spent the same amount of effort in looking for stickers in the no information and incorrect information conditions, $F(1, 118) = 1.16$, $p = .28$. These analyses confirm that the receipt of incorrect information and no information was more costly (in terms of effort) compared with receiving correct information. Indeed, receiving no information was just as costly as receiving incorrect information. This conclusion is supported by separate analyses of children's search time (incorrect information: $M = 47.99$ s, $SD = 35.94$; no information: $M = 32.34$ s, $SD = 31.29$; correct information: $M = 14.63$ s, $SD = 25.71$) and of the number of locations searched (incorrect information: $M = 6.56$, $SD = 3.25$; no information: $M = 6.80$, $SD = 3.66$; correct information: $M = 2.98$, $SD = 3.26$) (see supplementary material for details).

Children's judgments of the helpfulness of the information

Children in all three conditions rated the helpfulness of the note they were given. Children's ratings of the helpfulness of the note were scored in the same way as in Experiment 1. Note that 1 child did not provide a helpfulness rating. A few children provided an answer between the two response options offered to them. For example, when asked whether the information was helpful or not helpful, 1 child said, "in between." This answer was coded as 1.5. Both older and younger children used the full scale. Histograms of the distribution of responses are provided in the supplementary material. We used a 2 × 3 ANOVA with age (2: younger or older) and condition (3: correct information, no information, or incorrect information) as between-participants factors to analyze differences in children's

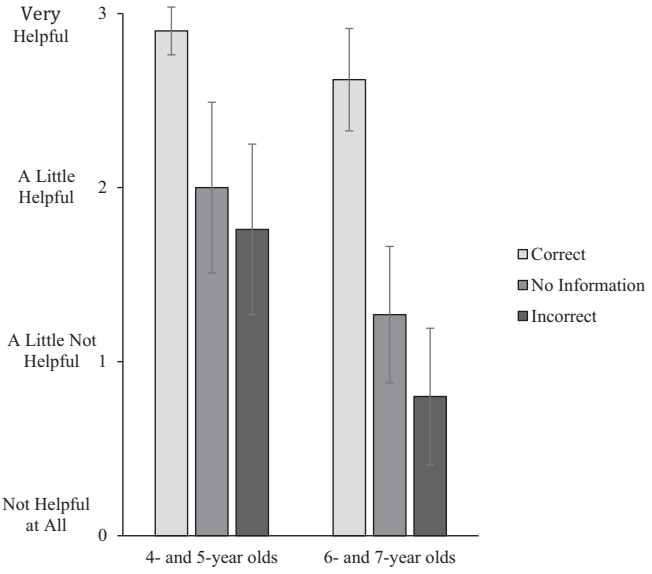

Fig. 4. Experiment 2: Mean helpfulness rating for the note children received in the correct information (gray), no information (dark gray), and incorrect information (black) conditions for younger and older children. Error bars represent 95% confidence intervals.

helpfulness ratings. This analysis revealed a significant main effect of condition, $F(2, 117) = 30.99$, $p < .001$, $\eta^2 = .31$, and a significant main effect of age, $F(1, 117) = 16.81$, $p < .001$, $\eta^2 = .08$, but no interaction of condition and age. The two main effects are visible in Fig. 4. All children rated the note they received in the correct information condition as significantly more helpful than the note they received in the no information condition, $F(1, 117) = 32.12$, $p < .001$, and in the incorrect information condition, $F(1, 117) = 57.49$, $p < .001$, but provided similar ratings in the no information and incorrect information conditions, $F(1, 117) = 3.33$, $p = .07$. Overall, younger children provided higher helpfulness ratings than older children, $F(1, 117) = 16.81$, $p < .001$. As further validation of these results, we reran this analysis using the initial dichotomous response of helpful or not helpful. The same pattern of results was found (see supplementary material for details). Thus, as expected, children perceived the receipt of no information as less helpful than correct information but approximately as helpful as incorrect information. In sum, children at both ages explicitly recognized the helpfulness of the information that guided their search.

Children's evaluation of the informant's intent

Recall that children were asked whether they thought the informant wanted them to find the hidden sticker or did not want them to find the sticker (1 child in the correct information condition and 2 children in the no information condition did not answer this question). Younger children attributed positive intentions to the informant in both the correct information (90%) and no information (82%) conditions, $\chi^2(2, N = 37) = 0.46$, $p = .50$. Younger children were also significantly more likely to attribute negative intentions to the informant in the incorrect information condition (48%) relative to the correct information condition (10%), $\chi^2(2, N = 41) = 7.00$, $p = .008$, and the no information condition (18%), $\chi^2(2, N = 38) = 3.75$, $p = .05$. A similar pattern was observed in older children. They attributed positive intent in the correct (95%) and no information (77%) conditions, $\chi^2(2, N = 43) = 2.89$, $p = .09$. Older children also attributed negative intentions to the informant in the incorrect information condition (70%) significantly more frequently relative to the correct information condition (5%), $\chi^2(2, N = 41) = 18.79$, $p < .001$, and the no information condition (23%), $\chi^2(2, N = 42) = 9.45$, $p = .002$. Thus, as expected, both younger and older children perceived the informant in the no information condition as having similar positive intentions as the informant in the correct information condition and perceived both informants as having more positive intentions than the informant in the incorrect information condition.

Relation between judgments of helpfulness of information and attributions of intent

When children received a note with a circled location in the correct and incorrect information conditions, they used that information to guide their search. This showed that they initially expected the information provided to be accurate. However, in the no information condition, children could not have had a similar initial expectation given the lack of information. To account for this difference, we approached the analysis of the relation between the ratings of helpfulness of the note and the informant's intentions differently. Specifically, we combined the conditions in which children could expect useful information (correct and incorrect information) and compared these with the no information condition. We expected that the helpfulness of the note would predict children's intent attributions for the combined correct information and incorrect information conditions, as it had done for Experiment 1, but not for the no information condition.

We again used logistic regressions to determine whether the helpfulness of the note, age, and the condition comparisons (expected useful information = correct and incorrect information conditions, coded as 1; did not expect useful information = no information condition, coded as 0) predicted children's attributions of positive or negative intent. We found a significant interaction between children's evaluation of the note's helpfulness and whether children expected to receive useful information (Table 3). When children expected to receive useful information, their perception of the note's helpfulness predicted their attributions of intent, odds ratio (OR) = 7.93, $p < .001$, 95% confidence interval (CI) [3.46, 18.20]. When children did not expect to receive useful information (i.e., no information condition), their perception of the note's helpfulness was not a significant predictor of their attributions of intent, $OR = 1.75$, $p = .16$, 95% CI [0.81, 3.78]. In the supplementary material, we replicated this analysis using the dichotomous coding of the note's helpfulness as helpful or not helpful. Also in the supple-

Table 3
Logistic regression model (log odds) predicting children's attribution of positive intentions to their informant as a function of whether they expected the note to be informative (i.e., correct information and incorrect information conditions) or not (i.e., no information condition), children's perception of the information's helpfulness, and children's age (continuous).

	Model 1
Expected useful information	−3.43 (0.99)***
Helpfulness of note	0.56 (0.39)
Expected useful information × Helpfulness of note	1.51 (0.56)**
Age	0.14 (0.29)
Constant	−0.29 (2.04)
Pseudo R^2	.39
N	120
Model *df*	4
χ^2	55.30***

Note. Standard errors are in parentheses.
** $p < .01$.
*** $p < .001$.

mentary material, we show the same analysis without collapsing the correct and incorrect information conditions together. Those results confirm that the note's helpfulness predicted children's attribution of informant intent only in the correct and incorrect information conditions.

In sum, when children received information they could use, they perceived the failure to provide useful information as a signal of negative intentions. However, when they did not receive any information from the informant because the informant was unable to finish the note, they did not perceive the failure to provide information as a signal of negative intentions.

Rewarding the informant

We analyzed the number of stickers children gave using a 2 × 3 × 2 ANOVA with age (2: younger or older), condition (3: correct information, no information, or incorrect information), and gender (2: female or male) as between-participants factors. This revealed a significant effect of condition, $F(2, 112) = 4.25$, $p = .017$, $\eta^2 = .06$, and a main effect of gender, $F(1, 112) = 4.11$, $p = .045$, $\eta^2 = .03$; girls were more generous than boys ($M = 3.68$ vs. $M = 2.94$). We found no effect of age on children's giving, $F(1, 112) = 0.99$, $p = .32$, and no interaction between age and condition, $F(2, 112) = 1.48$, $p = .23$. As depicted in Fig. 5, children gave similar amounts in the correct information and no information conditions, $F(1, 112) = 0.15$, $p = .70$. However, children gave less in the incorrect information condition compared with both the correct information condition, $F(1, 112) = 7.81$, $p = .006$, and the no information condition, $F(1, 112) = 0.5.69$, $p = .019$. In this experiment, it is unlikely that the condition effect simply reflects differences in the effort children expended across the three conditions because children provided more rewards in the no information condition than in the incorrect condition despite expending a similar effort across these two conditions. Nonetheless, we regressed the number of stickers children gave on the condition to which they were assigned, children's age (i.e., number of days/365), and the effort children expended in searching for the sticker (Table 4). The results of this analysis show that children's differential giving across conditions cannot be explained solely by differences in the effort children expended in the task.

General discussion

Across two experiments, we examined 4- to 8-year-old children's ability to evaluate and reciprocate toward an informant after using the information the informant provided. Specifically, we asked (a) when children are capable of evaluating the accuracy of information based on their use of it, (b) what inferences children draw about the informant's intentions based on the accuracy of the information, and (c) how this affects subsequent cooperation with the informant.

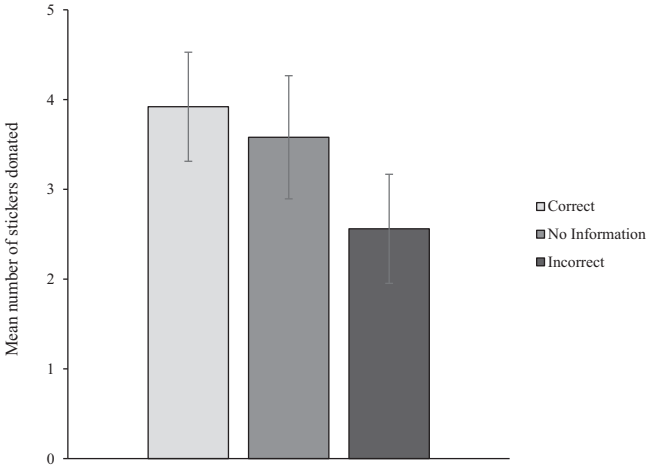

Fig. 5. Experiment 2: Mean number of stickers children donated to the informant in the dictator game in the correct information (gray), no information (dark gray), and incorrect information (black) conditions. Error bars represent 95% confidence intervals.

Table 4
Ordinary least squares regression model describing the relation between the number of stickers children donated, whether children received correct or incorrect information (reference category) or no information, children's age, children's gender (female = 1), and the effort children expended in searching for the stickers.

	Model 1
Correct information	1.55 (0.50)**
No information	1.03 (0.46)*
Age	0.27 (0.18)
Gender	0.66 (0.37)~
Search index	0.20 (0.23)
Constant	−0.14 (1.27)
R^2	.12
N	123
Model sum of squares	66.14
Residual sum of squares	502.53
Model *df*	5
Residual *df*	118
F	3.11*

Note. Standard errors are in parentheses.
~ $p < .10$.
* $p < .05$.
** $p < .01$.

All children spent less time in searching for the sticker when they received accurate information (relative to no information or incorrect information) and rated accurate information as most helpful. Children reasoned that the informant who provided them with correct information intended to help them but reasoned that the informant who provided them with incorrect information had not intended to help them. Children also attributed positive intentions to an informant who provided no information because the informant could not complete the note. Children's reward decisions paralleled their attributions of intent across the conditions. They similarly rewarded the informant who provided accurate information and the informant who unintentionally provided no information, and

they rewarded the inaccurate (and possibly deceptive) informant the least. Thus, children reciprocate the receipt of helpful information because they judge the provision of such information to be a signal of positive (cooperative) intentions.

Children rated correct information as more helpful than receiving no information and incorrect information. Importantly, they made these judgments after having used that information and without the help of a contrasting source of testimony. These results provide a strong test of children's ability to assess the helpfulness of information based on how well it helps them to achieve a goal. Although both age groups differentiated between the information they received, this distinction improved with age, with 6- and 7-year olds rating inaccurate information as clearly unhelpful. There are at least three possible explanations for this age-related difference. One possibility is that this difference reflects an age-related increase in children's ability to engage in counterfactual thinking—their ability to bring to mind what could have happened, that is, to think about the information that the informant could have given (see also Gweon & Asaba, 2017). Indeed, the ability to engage in counterfactual reasoning develops during this age (Burns, Riggs, & Beck, 2012). A second possibility is that younger children in the incorrect information condition struggled to evaluate the impact of the information they received because those children experienced both a longer search but also success (i.e., finding the sticker). Setting aside the success they experienced to focus on the effort they expended may have been difficult for younger children. Indeed, Gillis & Nilsen (2013) found that 4- and 5-year-olds, but not 6- and 7-year-olds, are reliant on outcome information to distinguish between an informant who provided sufficient information and an informant who provided insufficient information about the location of a hidden object. Moreover, the greater delay in children's search time in the incorrect information condition may have made it harder for younger children to connect their search experience with the cause of that experience—the receipt of incorrect or no information. A third possibility is that younger children were reluctant to criticize information provided as a "gift," whereas older children were more willing to do this.

When children received incorrect information, they more often stated that the informant had intended to mislead rather than to inform them. Importantly, when we examined the link between children's ratings of the helpfulness of the information and their inferences about the informant's intentions, children at all ages inferred negative intentions only when they could reasonably expect the information to be accurate and it was not. Regardless of age, when children received no information because the informant was unable to finish the note, they did not interpret the failure to provide useful information as a sign of negative intentions. This result is consistent with Robinson and Nurmsoo (2009) and Nurmsoo and Robinson (2009a), who found that children as young as 3-years-old excuse informants' past inaccuracies if those inaccuracies were unintentional because they were caused by a false belief or a lack of access to relevant data. The intention results also suggest that younger children in particular may be biased toward believing that an informant has positive intentions. In both experiments, younger children were still likely to ascribe positive intentions to the incorrect informant. However, older children clearly inferred negative intentions, with the majority saying that the incorrect informant did not want them to find the sticker. This age difference may reflect the fact that younger children need more information than older children to make inferences about the informant's intentions, particularly in cases like the one we tested where the cost of the inaccurate information to children was relatively minor. Indeed, a similar pattern has been observed in the literature on children's trait attributions. Older children need fewer behavioral examples than younger children to make trait attributions (Boseovski, Chiu, & Marcovitch, 2013; Ronfard & Lane, 2018). Thus, if the information children received was more costly, or if the cost of the information was more explicit, we would expect younger children to ascribe more negative intentions to the inaccurate informant.

Finally, we found that children differentially rewarded the informant based on their beliefs about the informant's intentions rather than based on their ratings of the helpfulness of the information they received. When given a chance to give rewards to the informant, children gave the least to the inaccurate informant and gave more to both the accurate informant and the informant who provided no information at all. The dissociation between the helpfulness of the information and informant intention in the no information condition provides evidence that the impact of the information on children's search was not the main factor that drove children's reward decisions. Despite recognizing

that the blank note was unhelpful and experiencing a prolonged search (indeed, a search just as long as that which resulted from incorrect information), children still assumed that the informant had positive intentions and rewarded the informant accordingly. Thus, our results suggest that by 4 years of age, children reward informants based on the inferences they make about an informant's communicative intentions based on their interaction with a single informant. Critically, we show that such inferences are built on children's expectation that a knowledgeable informant will provide accurate information. Our results suggest that children's tendency to avoid and act negatively toward an individuals who has harmful intentions (e.g., Dunfield & Kuhlmeier, 2010; Vaish et al., 2010) generalizes to communicative exchanges. This is noteworthy because the harm caused by the inaccurate information is often not immediate and tends to be less obvious.

Our results also suggest that, by 4 years of age, children appear to have the skills necessary to use the information they receive to assess an informant as a good or bad cooperative partner and to reward the informant accordingly. However, more research is needed to strengthen this conclusion and identify limits on children's use of accuracy and intent information when making reward decisions. Future studies can also clarify what precisely motivates children to engage in different degrees of reciprocity. For example, it is unclear whether children gave more to some informants and not others as a means of rewarding and punishing them for their past actions or whether children were signaling a desire for future interactions. Testing this would require a different paradigm but could be accomplished by making the expectation of future interaction explicit, as has been done in other studies (Sebastián-Enesco & Warneken, 2015).

In conclusion, young children can evaluate the value of the information they have been given based on their use of that information. They expect a knowledgeable informant to provide helpful information, and when they learn that the information they have been given is inaccurate, they question the informant's intentions and reward the informant less. These results suggest that preschool children not only recognize the value of information as a resource that is used in reciprocal exchanges but also use the information provided by others as a way to assess potential cooperative partners. This sophisticated ability can help children to navigate a world awash in information provided by informants who do not always have positive intentions.

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