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Observing an adult model can cause immediate improvement in preschoolers' knowledge judgments

Amanda R. Lipko-Speed[a,*], Stephanie Buchert[b], William E. Merriman[c]

[a] The College at Brockport, State University of New York, United States
[b] Longwood University, United States
[c] Kent State University, United States

ABSTRACT

We addressed whether preschoolers could learn how to make knowledge judgments by observing an adult make them correctly. In Experiment 1, children looked on as one adult answered another adult's questions about a hidden toy. In the modeling condition, the questions concerned whether the adult knew the identity of the toy. The model answered correctly and justified her answers by noting whether she had seen the toy being hidden. In the control condition, the model saw which toy was hidden on every trial and answered yes-no recognition questions about it. In both conditions, the children were then asked to make the kind of judgments that had only been demonstrated in the modeling condition. Younger children (*M*age = 3–4) were not affected by condition, but among the older children (*M*age = 4-1), those in the modeling condition made more accurate judgments and provided more perceptual access justifications than those in the control condition. Experiment 2 demonstrated that the modeling of knowledge judgments caused the accuracy of the older children's knowledge judgments to increase regardless of whether the model justified her judgments. Also, the modeling of perceptual access justifications increased the older children's tendency to give such justifications for knowledge judgments regardless of whether the justifications had been modeled for knowledge judgments or recognition responses.

1. Introduction

Ask a 3-year-old, "Do you know what a 'zav' is?" and he or she will likely answer with a very self-assured response of, "Yes!" Despite the fact that *zav* is a nonsense word that adults would readily admit to not knowing, young children tend to be overconfident when judging their own knowledge.

Preschool-age children's tendency to overestimate their own knowledge or ability has been demonstrated in a variety of tasks. These include memory prediction (e.g., Lipko, Dunlosky, & Merriman, 2009; Schneider, 1998), lexical knowledge judgment (e.g., Marazita & Merriman, 2004; Merriman, Lipko, & Evey, 2008), knowledge judgment based on perceptual access (e.g., Rohwer, Kloo, & Perner, 2012; Sodian & Wimmer, 1987), and perceptual, lexical, and memory confidence judgments (Hembacher & Ghetti, 2014; Lyons & Ghetti, 2011). Although even adults tend to overestimate their knowledge or ability (Fisher & Keil, 2015; Koriat & Bjork, 2005), the frequency and magnitude of these errors tends to decline over the course of childhood (Aguiar, Stoess, & Taylor, 2012; Lyons & Ghetti, 2011).

Our goal was to examine whether children's ability to make knowledge judgments based on perceptual access would improve after a brief observational learning experience. Would they become more likely to distinguish their states of ignorance from their states of knowledge if they first observed an adult make accurate reports of these states? In Experiment 1, we examined whether 3-year-olds and younger 4-year-olds would benefit from observing an adult not only make correct knowledge judgments about a hidden object, but justify these in terms of perceptual access. For Experiment 2, we examined whether older 3-year-olds and younger 4-year-

* Corresponding author at: The College at Brockport, State University of New York Psychology Department, 350 New Campus Drive Brockport, NY 14420, United States.
E-mail address: alipko@brockport.edu (A.R. Lipko-Speed).

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olds would benefit from only observing a model make correct judgments or from only observing a model offer perceptual access justifications.

No study has addressed whether preschool-age children's judgments of knowledge or belief might improve after observing a model make such judgments correctly. A microgenetic study by Amsterlaw and Wellman (2006) came the closest. Over 6–7 weeks, 3-year-olds repeatedly heard stories in which a character formed a false belief. For each story, the child predicted the character's utterance or action, then learned what the character actually said or did. One group was always asked to explain the character's behavior, whereas a comparison group was asked to do this for half of the stories. Only the first group showed an increased understanding of false belief on the posttest. Because participants received no explicit instruction or corrective feedback, both groups could be characterized as only having been exposed to a model of correct responding (i.e., the story character's responses). The results suggest that multiple sessions and a focus on explanation may both be necessary to promote successful observational learning of judgments of knowledge or belief.

The literature on attempts to directly train 3- and 4-year-olds to make such judgments also supports the possible importance of multiple training sessions and a focus on explanation (e.g., Clements, Rustin, & McCallum, 2000; Leece, Bianco, Demicheli, & Cavallini, 2014; Slaughter & Gopnik, 1996). In a review, Kloo and Perner (2008) concluded that training that informed children of the knowledge or belief states of various story characters and corrected the children whenever they misreported these states was only effective when the training was distributed over more than one session. Thus, children may only benefit if given sufficient time to "take in and integrate training experiences" (p. 124). Kloo and Perner also observed that direct training was more likely to succeed if it not only informed children of the correct answers, but also provided explanations for why these answers were correct. For example, Clements et al. (2000) found that 3- and 4-year-olds who received corrective feedback with explanations improved, but those who received corrective feedback alone did not. However, other studies have achieved positive training effects with corrective feedback alone (Hülsken, 2001; Slaughter & Gopnik, 1996; Slaughter, 1998).

There is good reason to hypothesize that older preschoolers may be able to learn how to make knowledge judgments that are based on perceptual access by observing someone else make these judgments accurately. By age four years, most children have acquired some understanding of how perceptual access affects another person's acquisition of knowledge. For example, they understand that another person will not know what is in a box after its contents have been switched (Hogrefe, Wimmer, & Perner, 1986; Lipowski & Merriman, 2011; Wellman & Liu, 2004) and that different kinds of knowledge are acquired by perception in different sense modalities (e.g., color knowledge through vision) (O'Neill & Chong, 2001). Thus, 4-year-olds may be able to identify the critical differences in perceptual access that cause a model to claim to know or not know in various situations.

Although there have been no studies of whether young children can learn how to make knowledge or belief judgments from a model, there is evidence that they can learn to behave according to a conceptual rule from a brief session in which they simply observed an adult follow the rule (Wang, Meltzoff, & Williamson, 2015; Williamson, Jaswal, & Meltzoff, 2010). The behavior and the rule in these instances were quite different from the behavior and rule that are the focus of the current study, however. In Williamson et al. (2010), Experiment 1), 3-year-olds who observed an adult sort an array of objects by color rather than by shape were more likely to adopt this sorting rule when they performed the task themselves. Likewise, in Experiment 2, 3-year-olds who watched an adult sort an array of objects by the sounds that the objects made were more likely to adopt this sorting rule. Wang et al. (2015) found that 4-year-olds, but not 3-year-olds learned to sort objects by weight after observing an adult use this sorting strategy. The investigators suggested that weight may just be a more difficult dimension for 3-year-olds to process than color or object sound. Although sorting objects is quite a different task from judging one's knowledge based on perceptual access, one similarity is that successful performance involves applying a conceptual rule to a set of decisions. The demonstrations by Williamson and colleagues at least establish a precedent in which preschool-age children learned to apply a conceptual rule from a single session of modeling that did not include explanations.

2. Experiment 1

We examined whether a single session of modeling that included explanations would cause an immediate improvement in preschoolers' knowledge judgments. The children had to judge whether they knew the identity of a toy that had been hidden in a box. Children five years old and younger have been observed to overestimate the knowledge that they gain from observing some hiding events of this kind (Rohwer et al., 2012; Sodian & Wimmer, 1987). For example, in Rohwer et al. (2012), 3- to 7-year-olds watched a toy being hidden in a box (complete knowledge), received no information about the toy hidden in a box (complete ignorance), or viewed two toys and then learned that one of them had been hidden in a box (partial knowledge). When asked whether they knew what toy was in the box, all groups responded accurately on complete knowledge and complete ignorance trials, but only children older than 5 years consistently acknowledged their ignorance on partial knowledge trials. A similar type of error has been observed in tasks requiring children to evaluate possible solutions to problems. Children under age 6 often identify a single solution to a particular problem (Beck, McColgan, Robinson, & Rowley, 2011, Experiment 2; Kloo, Rowher, & Perner, 2017, Experiment 1; Robinson, Rowley, Beck, Carroll, & Apperly, 2006), or say that they know how the problem was solved (Fay & Klahr, 1996; Klahr & Chen, 2003), when they have not received enough information to eliminate alternative solutions.

Regarding judgments concerning a hidden object, Rohwer et al. (2012) proposed that children under six years tend to decide that they know its identity if they can readily think of a plausible identity. On complete ignorance trials, where they receive no information about what the experimenter might be hiding, they later decide that they do not know what is in the box because no particular object comes to mind when they think about what is in there. On complete knowledge trials, where they see what the experimenter puts in the box, they later decide that they know what is in the box because this object comes to mind when they think about what is in there. On partial knowledge trials, where they see the experimenter take two objects behind the screen and hear her say that she put one in the box, they later decide that they know what is in the box because one of these objects comes to mind when they think about what is in there. Fay and Klahr (1996) made a similar proposal, called the *positive capture strategy*, to explain why children often decided that they knew how a problem was solved before they received enough evidence to eliminate alternative solutions. The momentary evidence in support of one solution so captured attention that they did not consider whether another solution might also be correct.

The training studies reviewed by Kloo and Perner (2008) involved training 3- and 4-year-olds to make knowledge or belief judgments that nearly every child has mastered by the fifth birthday. The ability to judge one's knowledge in situations where one has partial, but inadequate knowledge appears to be a later achievement (Klahr & Chen, 2003; Rohwer et al., 2012; Sodian & Wimmer, 1987). Only one published study (Klahr & Chen, 2003, Experiment 2) has attempted to train children to make this judgment. The training involved giving 4- and 5-year-olds corrective feedback and explanations regarding their judgments under conditions of sufficient knowledge, partial knowledge, or no knowledge. Nearly every 5-year learned to make correct judgments on partial knowledge trials during the first training session. No 4-year-old learned this rapidly, but about half learned to do so after completing two training sessions, which occurred a week apart. So the result for the 4-year-olds is consistent with the suggestion, based on Kloo and Perner (2008) review, that this age group only benefits if training includes explanations and occurs over more than one session.

The tasks in Experiment 1 were modeled after ones used by Rohwer et al. (2012).

Children in the modeling condition first observed an adult make four judgments correctly, two in partial knowledge tasks and two in complete knowledge tasks. Children in the control condition observed an adult answer four yes-no recognition questions about the identity of a toy that they had seen hidden. The adult model did not receive any feedback on her own performance from the adult tester. Because children received follow-up questions about their judgments in Rohwer et al. (2012) procedure, these same questions were posed to the adult model. These questions also gave the model an opportunity to explain how her judgments were based on perceptual access.

We included 3-year-olds and younger 4-year-olds for several reasons. First, some knowledge judgments that are based on perceptual access show marked improvement over this age range (Hogrefe et al., 1986; Wellman & Liu, 2004; Wimmer, Hogrefe, & Perner, 1988). Also, 4-year-olds, but not 3-year-olds have shown some understanding of how different kinds of knowledge are acquired via perception in different sense modalities (O'Neill & Chong, 2001). Thus, younger 4-year-olds might be more likely than 3-year-olds to identify the critical difference in perceptual access that causes a model to claim to know on complete knowledge trials, but not know on partial knowledge trials. Also, 4-year-olds' confidence judgments regarding their recognition memories tend to be greater for correct than for incorrect memories, whereas 3-year-olds' do not (Hembacher & Ghetti, 2014; Liu, Su, Xu, & Pei, 2018). Finally, 4-year-olds have outperformed 3-year-olds on some tests of implicit awareness of the inadequacy of partial knowledge (Kim, Paulus, Sodian, & Proust, 2016; Kloo et al., 2017, Experiment 2).

2.1. Method

2.1.1. Participants

Sixty-two preschoolers (*M*age = median age = 3 years, 9 months; range = 3 years, 1 month to 4 years, 6 months; 30 boys) who attended preschools and daycare centers in the surrounding areas of Rochester, NY and Farmville, VA participated individually in a quiet classroom.

2.1.2. Materials and procedure

Children were assigned to either a modeling condition or a control condition. Conditions were matched for age, t (59) = 0.71, p = 0.48. The procedure included two parts. During the first part, children in the modeling condition observed an adult perform a knowledge judgment task, while those in the control condition observed this same adult perform a recognition task. For the second part, all of the children performed the knowledge judgment task.

2.1.2.1. Part 1: modeling condition. One adult served as the tester and the other adult served as the model. The tester told the child to watch as she and the other adult played a "yes-no game." The tester told the model, "I am going to show you two toys and then hide one in a box. Then I am going to ask you whether you know which toy is in the box. Just say, 'Yes' or 'No.'" Four trials followed, each involving a different pair of toys (e.g., a cow and a plane). On each trial, the tester presented the toys, asked the adult to identify them, then moved the toys behind a trifold screen. The tester then drew the model's attention to an opaque box that she placed in front of the screen. On two randomized trials (*partial knowledge*), the tester then moved the box behind the screen and announced that she was hiding one of the two toys in it. After closing the lid (behind the screen), she brought the box out and said, "Ok, I've hidden one of the toys in the box. Do you know which toy is inside the box?" A second adult responded, "No." The tester requested a justification: "Why don't you know which toy is inside?" The adult cited her lack of perceptual access to the hiding event: "I didn't see which one you put inside the box."

For the other two randomized trials (*complete knowledge*), the tester did not move the box behind the screen, but kept it in full view of the model. The tester brought out one of the two toys from behind the screen, held it in front of the model for a second, then put it in the box and closed the lid. The tester said, "Ok, I've hidden one of the toys in the box. Do you know which toy is in the box?" The other adult responded, "Yes." The tester then asked her to identify it, and the adult said the name of the toy that she had seen hidden in the box. The tester asked, "Do you really know that or are you just guessing?" The adult responded, "I really know that." The tester requested a justification: "How do you know that there is a (cat) inside?" The adult cited her perceptual access to the hiding event: “I saw you put the (cat) in the box.”

2.1.2.1.1. Part 1: control condition. As with the modeling condition, the tester told the child to watch as she and the other adult played a “yes-no game.” The model then received two trials. On each trial the tester hid a toy behind a trifold screen and then posed one “yes” and one “no” question about the toy’s identity. For example, the tester asked the other adult, “Is there an apple back here?” (Correct answer: “Yes.”) Is there a ball back here?” (Correct answer: “No.”) The other adult answered both questions correctly on each trial.

2.1.2.2. Part 2: testing phase. The tester asked the child if he or she would like to play the same game (in the modeling condition)/ different game (in the control condition). She then gave the child the same instructions and questions as were presented to the adult in Part 1 of the modeling condition. The two partial knowledge and two complete knowledge trials involved different pairs of toys than had been used in Part 1. Whenever a child responded “Yes” to the initial knowledge question (correctly or incorrectly), the tester asked the child to identify the toy, and then asked, “Do you really know that or are you just guessing?” and “How do you know that there is a (label the child had provided) inside?” Whenever the child responded “No” to the initial knowledge question, the tester asked, “Why don’t you know which toy is inside?”

2.2. Results and discussion

The main dependent variable was the frequency of correct response (max = 4) when asked, “Do you know which toy is inside the box?” The correct response was, “Yes” on complete knowledge trials and, “No” on partial knowledge trials. To examine the effect of age, children in each condition were split by median age. In the modeling condition, M_{age} was 3 years 4 months (range = 3-1 to 3–8; $N = 14$) in the younger group and 4 years 1 month (range = 3–9 to 4–6; $N = 15$) in the older group. In the control condition, M_{age} was 3 years 5 months (range = 3-2 to 3–8; $N = 15$) in the younger group and 4 years 2 months (range = 3–9 to 4–6; $N = 18$) in the older group. (We dichotomized age for the purpose of conducting analyses of variances. Results of correlational analyses involving age-in-months supported the same conclusions as the results of the analyses of variance.)

We conducted a 2 (age) x 2 (condition) analysis of variance, which yielded significant effects of condition, $F(1, 58) = 4.46$, $p = 0.039$, $\eta^2 = 0.07$, and age x condition interaction, $F(1, 58) = 10.37$, $p = 0.002$, $\eta^2 = 0.15$. As Fig. 1 illustrates, the younger children responded correctly as often in the modeling condition ($M = 2.57$, $SD = 0.94$) as in the control condition ($M = 2.80$, $SD = 0.86$), $t(27) = 0.68$, $p = 0.50$. In contrast, the older children responded correctly more often in the modeling condition ($M = 3.60$, $SD = 0.63$) than in the control condition ($M = 2.50$, $SD = 0.79$), $t(31) = 4.37$, $p = 0.0001$, Cohen’s $d = 1.53$. Performance exceeded chance (2.00) in each condition in each age group, $ts > 3.38$, $ps < 0.01$.

All but six children responded correctly on both complete knowledge trials. These six were roughly evenly distributed across the four age x condition groups (zero in the older child

- modeling group and two in each of the other groups). Therefore, the locus of the interaction effect was the partial knowledge trials. The level of performance on the complete knowledge trials was comparable to that of previous studies (Rohwer et al., 2012; Sodian & Wimmer, 1987). So too was the level of performance on the partial knowledge trials, with the exception of the older children in the modeling condition. The majority of the children in the latter group responded correctly on both partial knowledge trials (67%), whereas only small minorities did so in the other three groups (17–33%).

When children said, “Yes” in response to a “Do you know” question, the tester then asked them whether they really knew this or were just guessing. For complete knowledge trials, “really knew” was considered the correct response because children had seen the toy hidden.

Although this response was more frequent in the modeling than in the control condition in both the older child group ($M = 1.60$, $SD = 0.74$, and $M = 1.17$, $SD = 0.99$, respectively; maximum = 2) and younger child group ($M = 1.00$, $SD = 0.96$, and $M = 0.73$, $SD = 0.88$, respectively), the effect of condition was not significant, $t(60) = 1.45$, $p = 0.15$. The effect of age was significant, however, $t(60) = 2.18$, $p = 0.03$, Cohen’s $d = 0.55$.

On complete knowledge trials, whenever children indicated that they really knew the identity of the toy, the tester asked them to justify this response (i.e., “How did you know the (bus) was inside?”). On partial knowledge trials, whenever children indicated that they did not know the identity of the toy, the tester asked them to justify this response (i.e., “Why don’t you know what is inside?).

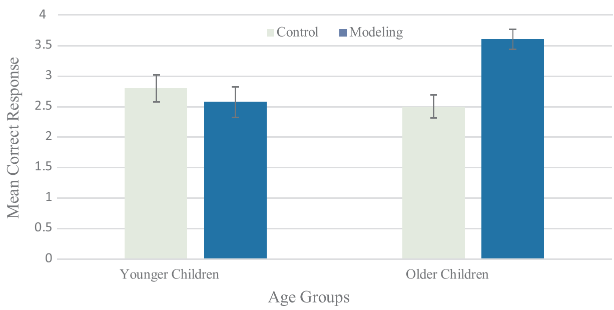

Fig. 1. Mean number of correct knowledge judgments made by children in Experiment 1. Error bars represent standard errors of the mean.

Just as Rohwer et al. (2012) found, children rarely gave perceptual access justifications (e.g., "Because I [saw/did not see] what you put it in there"); only 21 children ever offered one on a complete knowledge trial and only 16 ever offered one on a partial knowledge trial. However, in the older child group ($n = 33$), such justifications were offered more frequently in the modeling condition ($M = 1.89$, $SD = 0.49$) than in the control condition ($M = 0.61$, $SD = 0.98$), Kendall τ c = 0.500 (SE = 0.161), p = 0.002. In the younger child group ($n = 29$), such justifications were as rare in the modeling condition ($M = 0.79$, $SD = 1.12$) as in the control condition ($M = 0.60$, $SD = 1.18$), Kendall $\tau_c = 0.138$ (SE = 0.181), $p = 0.44$.

In sum, modeling judgments that were based on perceptual access had no effect on younger 3-year-olds, but caused the judgments of a group of older 3-year-olds and younger 4-year-olds to improve. Modeling also increased the older children's tendency to offer perceptual access justifications for their judgments. These positive effects challenge the speculation, based on previous attempts to teach preschoolers to make knowledge or belief judgments (Amsterlaw & Wellman, 2006; Klahr & Chen, 2003; Kloo & Perner, 2008), that training would only succeed if it were distributed over multiple sessions. Our results are consistent, however, with the positive effects of a single session of modeling that have been observed for various object sorting tasks (Wang et al., 2015; Williamson et al., 2010).

The goal of Experiment 2 was to separate the effect of modeling knowledge judgments from the effect of modeling perceptual access justifications. We only tested children who were in the same age range as the older children in Experiment 1 because the younger 3-year-olds in that experiment did not benefit from the modeling of judgments with justifications. It is unlikely that only modeling judgments or only modeling of perceptual access justifications would help younger 3-year-olds.

3. Experiment 2

3.1. Method

3.1.1. Participants

Forty-eight preschoolers (*M*age = median age = 4 years, 2 months; range = 3 years, 9 months to 4 years, 8 months; 25 girls) who attended preschools and daycare centers in the surrounding areas of Rochester, NY and Farmville, VA participated individually in a quiet classroom. Twelve children (5–7 boys) were assigned to each cell in the 2 (modeled task: knowledge judgment vs. recognition) x 2 (modeled justification: perceptual access vs. none)

factorial design of the experiment. The mean age in each cell was within one month of the overall mean (4 years, 2 months).

3.1.2. Materials and procedure

The procedure for Experiment 2 was similar to that of Experiment 1. For the partial knowledge trials, the children did not watch as the toy was hidden in the box; for the complete knowledge trials, they did. In all four conditions, the partial and complete knowledge tasks that the children themselves performed during the second phase were the same as in Experiment 1, except that the number of each type was increased from two to three. The following describes what the child observed the model do and say during the first phase of each condition.

3.1.2.1. Modeled knowledge judgment with justification. The model's activities were the same as in the modeling condition of Experiment 1. The model gave a correct "Yes-No" response when asked whether she knew what toy was in the box on two partial knowledge and two complete knowledge trials. She indicated for "Yes" responses that she really knew, and provided a perceptual access justification for all responses.

3.1.2.2. Modeled knowledge judgment without justification. The model's activities were the same as in the condition just described, except that she did not provide justifications for her judgments. When asked how she knew the identity of the toy in the box (on complete knowledge trials) or why she did not know it (on partial knowledge trials), the model said "Hmmm…" and looked away as if thinking about the question. The tester waited a few seconds, then presented the next trial ("OK, here are two new toys.…).

3.1.2.3. Modeled recognition with justification. The model's activities were somewhat similar to those in the control condition of Experiment 1. The model participated in four trials. On each trial the tester hid a toy behind a screen, and then posed either a "Yes" question (two trials) or a "No" question (two trials) about the toy's identity. For example, the tester asked the model, "Is there an apple back here?" (Correct answer: "Yes.") or Is there a ball back here?" (Correct answer: "No.") After the model answered this recognition question correctly, the tester asked, "Do you really know that or are you just guessing?" The model replied, "I really know that." The tester then asked, "How do you know that?" The model provided a perceptual access justification, "Because I saw you put [e.g., an apple] in the box." Note that on both "Yes" and "No" trials, the object mentioned in the justification was the one that the model had seen placed behind the screen.

3.1.2.4. Modeled recognition without justification. The model's activities were the same as in the condition just described, except that she was not asked to provide justifications for her responses to the recognition questions.

3.2. Results and discussion

The main dependent variable was the frequency of children's correct response (max = 6) when asked, "Do you know which toy is

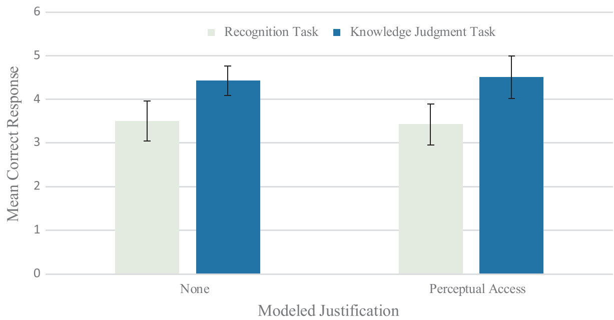

Fig. 2. Mean number of correct knowledge judgments made by children in Experiment 2. Error bars represent standard errors of the mean.

inside the box?" A 2 (modeled task: knowledge judgment vs. recognition) x 2 (modeled justification: perceptual access vs. none) analysis of variance yielded a significant main effect of modeled task, $F(1, 44) = 5.18$, $p = 0.028$, $\eta^2 = 0.10$. Neither the main effect of modeled justification nor the two-way interaction was significant, both $F < 1$. As Fig. 2 illustrates, children who observed the adult make knowledge judgments about hidden objects made more correct knowledge judgments themselves ($M = 4.46$, $SD = 1.41$) than children who observed the adult answer recognition questions about hidden objects ($M = 3.46$, $SD = 1.56$). The frequency of correct response exceeded chance in the former group, $t\,(23) = 5.07$, $p < 0.001$, but not in the latter group, $t\,(23) = 1.44$, $p > 0.10$. Thus, we replicated the positive effect shown by the 4-year-olds in Experiment 1. Moreover, the effect was just as strong when the adult modeled correct knowledge judgments without offering any justifications as when the adult modeled these judgments and justified them in terms of perceptual access.

As in Experiment 1, children made accurate judgments on complete knowledge trials regardless of whether they had first observed a model make knowledge judgments ($M = 2.58$, $SD = 0.83$) or answer recognition questions ($M = 2.46$, $SD = 0.78$), $t\,(46) = 0.54$, $p = 0.59$. The locus of the effect of modeled task was the partial knowledge trials. On these trials, when asked whether they knew which toy was in the box, children who had observed the model make knowledge judgments said "No" more often ($M = 1.88$, $SD = 1.19$) than children who had observed the model answer recognition questions ($M = 1.00$, $SD = 1.28$), $t(46) = 2.45$, $p = 0.02$, Cohen's $d = 0.71$. Sixty-seven percent in the former group responded correctly on at least two of these three trials, whereas only 29% did so in the latter group.

A 2 (modeled task) x 2 (modeled justification) analysis of variance was conducted on how frequently children reported that they "really knew" the identity of the hidden toy on complete knowledge trials. The effect of modeled task was significant, $F\,(1, 44) = 5.05$, $p = 0.03$, $\eta^2 = .10$. Children who had observed the model make judgments of her knowledge gave this report ($M = 2.21$, $SD = 1.14$) more frequently than children who had observed the model answer recognition questions ($M = 1.46$, $SD = 1.21$). Neither the effect of modeled justification, $F(1, 44) = 2.24$, $p = 0.14$, nor the two-way interaction, $F(1, 44) = 1.56$, $p = 0.22$, was significant. Thus, exposure to an adult who modeled knowledge judgments, even one who did not justify her judgments, promoted children's tendency to report that they really knew which toy was in the box on trials in which they did indeed know it.

We also analyzed how frequently children offered perceptual access justifications in response to probes about the source of their knowledge/ignorance (i.e., "how do you know"/"why don't you know"). All participants were included in this analysis. Because the distributions of these frequency scores were either positively skewed or bimodal in each cell in the 2 (modeled task) x 2 (modeled justification) design, non-parametric tests were used instead of an analysis of variance. In the modeled knowledge judgment condition, children who had heard the model provide perceptual access justifications for her judgments offered such justifications more frequently ($M = 3.00$, $SD = 2.73$) than children who had heard the model provide no justifications for her judgments ($M = 1.25$, $SD = 2.14$), Kendall $\tau_c = 0.396$ (SE = 0.199), $p = 0.046$. In the modeled recognition condition, there was a similar trend, but it was not significant; the means were 2.08 ($SD = 2.15$) and 0.92 ($SD = 1.24$), respectively, Kendall $\tau_c = 0.354$ (SE = 0.208), $p = 0.088$. This contrast between conditions is not significant, and is likely an artifact of the higher frequency of correct knowledge judgments in the modeled knowledge judgment condition than in the modeled recognition condition. (Children rarely offered a perceptual access justification for an incorrect knowledge judgment.) The mean proportion of correct judgments for which children also offered perceptual access justifications was about twice as high among the children in each condition who had heard the model provide these justifications (0.53 in the modeled knowledge judgment condition and 0.56 in the modeled recognition condition) compared to children who had heard model give correct answers, but not justify them (0.27 in the modeled knowledge judgment condition and 0.21 in the modeled recognition condition).

In sum, there was evidence that providing perceptual access justifications, whether for knowledge judgments or recognition decisions, increased children's tendency to provide such justifications themselves for the correct knowledge judgments that they made. As documented in the previous analysis, however, there was no evidence that providing perceptual access justifications enhanced the effect that the modeling of knowledge judgments had on children's tendency make correct knowledge judgments.

4. General discussion

In Experiment 1, a group of older 3- and younger 4-year-olds, but not a group of younger 3-year-olds benefited from observing an adult who modeled correct knowledge judgments about a hidden toy and offered perceptual access justifications. The older group benefited in two ways. First, they made these same kind of knowledge judgments themselves more accurately than children who had only observed an adult answer recognition questions about a hidden toy. These two conditions did not differ on complete knowledge trials in which they actually saw the tester place a toy in a box; both tended to report that they knew its identity on these trials. However, the older children who had observed the model were more likely to admit their ignorance on partial knowledge trials in which they had seen the tester select two toys, but had not seen which one she placed in a box. The second way in which the older children benefited was that they were more likely to offer perceptual access justifications for their knowledge judgments. They were more likely to justify "Yes" judgments by reporting that they had seen the toy being put in the box and to justify "No" judgments by reporting that they had not seen which toy had been put in the box.

Experiment 2 demonstrated that the two positive effects of modeling on the older children in Experiment 1 most likely derived from different aspects of the model's performance. The positive effect on the accuracy of knowledge judgments likely stemmed from having observed the model make accurate knowledge judgments. The children showed this effect in Experiment 2 even when the model provided no justifications for her judgments. The other positive effect on the older children in Experiment 1 – an increased tendency to provide perceptual access justifications for correct judgments – most likely resulted from observing the model provide these kinds of justifications. The children showed this effect in Experiment 2 even when the model had offered these justifications for answers to recognition questions. Thus, each benefit was restricted to the type of judgment or justification that had been modeled.

These benefits were the immediate result of a brief session of modeling. The older children did not need multiple sessions or an extended time period to mull over what they had observed before showing increased judgment accuracy or an increased tendency to offer a perceptual access justification. This finding contrasts with the results of studies in which 4-year-olds received a single session of training in knowledge or belief judgment via corrective feedback (see review by Kloo & Perner, 2008, and first session results for 4-year-olds in Klahr & Chen, 2003, Experiment 2). However, the finding is similar to the results of studies in which physical concepts have been trained via a single session of modeling (Wang et al., 2015; Williamson et al., 2010). Modeling may be a more effective teaching technique than direct training for some concepts or procedures, but not for others. However, the question of whether modeling is more effective than other training procedures for any type of content cannot be answered without further research that directly compares these methods.

Why did the younger 3-year-olds fail to benefit from modeling? This age group tends to have more difficulty than older children inhibiting a bias to say "yes" in response to yes-no questions (Fritzley & Lee, 2003). Moriguchi, Okanda, and Itakura (2008) also found this difficulty to be greater among children with smaller receptive vocabularies or who had difficulty switching rules in a dimensional card-sorting task. The younger 3-year-olds in our investigation may also have been less willing to admit to not knowing something, although we are not aware of any empirical studies of this possibility. These dispositions may be so strong that younger 3-year-olds cannot overcome them even if they hear an adult say "no" in response to some "Do-you know" questions.

We doubt that the younger children's failure to benefit from modeling was completely due to their difficulty overcoming response biases, however. Rohwer et al. (2012) found that 3-year-olds were willing to admit that they did not know the identity of a hidden object when they had not seen any of the potential hiding objects (i.e., in complete ignorance tasks). Also, Kim et al. (2016) found that 3-year-olds did not distinguish between partial and complete knowledge tasks in a version of Rohwer et al. (2012) paradigm that did not require them to explicitly admit ignorance. In this version, a second adult ("Max") was present during the hiding events, but screens prevented him from seeing what was happening. After each hiding event, the experimenter said, "Max wants to know what's inside the box. Can you help him?" Three-year-olds were no less likely to agree to inform Max on partial knowledge trials than on complete knowledge trials. Importantly, they did not show a "yes" bias; they agreed to inform Max on approximately 0.45 of each type of trial. These findings suggest that failure to experience less certainty in a belief that is based on partial knowledge compared to a belief based on complete knowledge may also contribute to 3-year-olds' failure to benefit from observing a model make correct knowledge judgments and offer perceptual access justifications for these judgments.

In contrast to their results for 3-year-olds, Kim et al. (2016) found that 4-year-olds were less likely to agree to inform Max on partial knowledge trials than on complete knowledge trials. A similar result was obtained by Kloo et al. (2017), Experiment 2). Children age 3 through 7 years received several trials in which they were shown two or three identical cups. The children were asked to pick the cup that had a star under it, which could be determined by peeking through tiny holes in the cups. However, on one trial (the complete knowledge trial), children did not need to peek because they were first shown where the star was hidden. Nearly every child who was 4 years old or older choose this cup on this trial without peeking, but peeked before choosing on the other trials. In contrast, only about a third of the 3-year-olds showed this response pattern.

These findings are consistent with the possibility that the group of older 3- and younger 4-year-olds in the current investigation benefitted from modeling because children this age tend to be less certain of a belief based on partial knowledge compared to a belief based on complete knowledge. They may infer from the model's responses that they should claim to know what toy is in the box only if they are highly confident in their belief about what is in the box. In other words, from observing the model, they might simply adopt a more conservative criterion for the degree of certainty needed to support the claim that they know what toy is in the box. This proposal also fits with other evidence that an ability to explicitly represent one's own and others' degree of certainty develops around the fourth birthday. Four-year-olds' confidence judgments regarding their own recognition memories tend to be greater for correct than for incorrect memories, whereas 3-year-olds' do not (Hembacher & Ghetti, 2014; Liu et al., 2018). Four-year-olds, but not 3-year-olds have learned how various pairs of linguistic expressions contrast in the degree of certainty that they express (e.g., *know that* versus *think that*; *must* versus *could*) (Moore, Bryant, & Furrow, 1989; Moore, Pure, & Furrow, 1990).

On the partial knowledge trials in which the model claimed that she did not know which toy was in the box, the older children may have gone beyond merely noting that they also had some doubt that they themselves knew. They may have been prompted by this doubt to check their memory for the event in which one of the toys was placed in the box. This may have led them to note that although they recalled hearing the experimenter announce that she was putting one of the toys in the box, they did not see which toy she picked. They might have then reasoned that because they had not seen the hiding event, they could not know which toy was in the box. Four-year-olds tend to pass, and 3-year-olds tend to fail, tests of memory for the sense modality through which they acquired specific pieces of information (Gopnik & Graf, 1988; O'Neill & Gopnik, 1991). Four-year-olds also have a better understanding of the difference between the kinds of information that can be acquired via different sense modalities (O'Neill & Chong, 2001).

Another reason that modeling may have helped the older children is that they may have a greater appreciation of the inadequacy of partial knowledge for other persons than they do for themselves. In contrast to the consistent finding that most 4-year-olds and many 5-year-olds claim to know an answer when they only have partial knowledge (e.g., Klahr & Chen, 2003; Rohwer et al., 2012; Sodian & Wimmer, 1987), very few children in this same age range predict that a puppet who only has partial knowledge will know the answer (Pillow, Hill, Boyce, & Stein, 2000, Experiments 1 and 3; Ruffman, 1996, Experiment 1; Sodian & Wimmer, 1987). Because the older 3- and younger 4-year-olds in our investigation saw an adult confirm that she did not know an answer on trials in which she had only partial knowledge, they may have been led to apply their understanding of why she made this claim to their assessments of their own knowledge states on these same type of trials. That is, if they comprehended the model's claim of ignorance by noting that she did not see which toy was placed in the box, this act of comprehension may have disposed them to use the same reasoning to infer that they too must be ignorant on such trials.

Rohwer et al. (2012) proposed that the evidence that children come to appreciate the inadequacy of partial knowledge for other minds before they appreciate it for their own minds poses a challenge for simulation accounts of the development of theory of mind (e.g., Harris, 1992), but not for theory-theory accounts (e.g., Gopnik & Wellman, 2012). According to simulation accounts, children predict the mental states of others in various situations by projecting what their own mental states would be in those situations. Thus, there should be no cases in which children's assessments of other minds are more accurate than their assessments of their own minds. In contrast, according to the theory-theory account, children may use different evidence for characterizing the mental states of others than they do for characterizing their own mental states. Also, advances in children's understanding of other minds may even stimulate advances in their understanding of their own minds. Our finding that observing a model make accurate knowledge judgments prompted children to make accurate knowledge judgments themselves provides further support for this account.

Modeling may have helped the children to understand why it is wrong to claim to know something in a partial knowledge situation even if an answer comes to mind readily and evokes a feeling of knowing. They may not have already understood that in such circumstances, they actually do not know whether the answer is correct because they did not have adequate informational access. They may need modeling, or some other form of instruction, to learn that even if they recall one of the two toys that could have been put in a box, they should not claim to know that toy is in there unless they have a reliable basis for holding this belief.

Wang et al. (2015) reported age differences in the observational learning of a sorting rule that parallel our own. In their experiment, 4-year-olds, but not 3-year-olds were more likely to sort a set of objects by weight if they first observed an adult sort a different set of objects by weight. The key element here may be the requirement to shift attention away from a dominant feature of a task. In Wang et al.'s study, 4-year-olds may have been better able than 3-year-olds to shift attention away from visible properties of the objects, such as shape and color, and so discover that the model was sorting the objects based on a non-visible property (weight). In our investigation, the older children may have been better able than the younger ones to shift attention away from the identity of the toy that first came to mind when asked the knowledge question (Fay & Klahr, 1996; Rohwer et al., 2012). Consequently, they focused on how the model was responding based on whether she had actually seen one of the toys put in the box.

In Experiment 2, the effect of modeling knowledge judgments on the accuracy of children's knowledge judgments was no stronger when the model justified her judgments then when she did not justify them. Such a finding contrasts with the general finding of studies in which researchers have attempted to teach knowledge or belief judgments directly. As Kloo and Perner (2008) noted in their review, such instruction has tended to be more effective when justifications are included. Children may be better able to discover the basis for correct judgments when an adult merely models such judgments than when an adult tells them what these judgments should be. In the studies in which children increased their tendency to sort objects by a particular rule after observing an adult sort by that rule (Wang et al., 2015; Williamson et al., 2010), the adult did not describe the rule she was following nor offer any explanation for her sorting decisions. When children observe an adult respond in an unexpected way to another adult's questions, they may not expect the adult to justify her responses. In contrast, when an adult tells them that they themselves have made an incorrect response, they may expect the adult to explain why. If the adult does not do this, the children may be surprised or puzzled, which might well interfere with their figuring out the explanation on their own.

On the other hand, there may be something unique to false belief judgments, which have been the primary focus of the direct training studies (Kloo & Perner, 2008), that makes it important to provide explanations when training them. An important question for future research is whether children would show an immediate benefit from observing a model merely make correct false belief judgments, and whether the provision of justifications would enhance this effect.

The explanations we have considered for why modeling accurate knowledge judgments may have caused an increase in the accuracy of children's knowledge judgments do not strictly entail a concomitant increase in their tendency to justify these judgments appropriately. If the effect on knowledge judgment accuracy was solely due to children adopting a stricter confidence criterion for claiming knowledge, then they might not have even thought about perceptual access when making these judgments. Even if the effect was caused by an increase in children's tendency to base judgments on perceptual access, they might not have become aware that this was what they were doing. Finally, even if they did become aware that they were basing judgments on perceptual access, they might not have interpreted the experimenter's requests for justifications as invitations to describe how they did this. That is, they might not have interpreted "how did you know?" as an invitation to describe the process by which they came to know or "why didn't you know?" as an invitation to describe how a process that would have caused them to know did not occur.

These possibilities are also compatible with our finding that modeling perceptual access justifications for recognition judgments had just as strong an effect on children's justifications for knowledge judgments as modeling perceptual access justifications for knowledge judgments. In both conditions, the model showed how to answer the experimenter's requests for justifications by describing the visual process that caused her to acquire knowledge. Even in the modeled recognition condition, although the model was not asked whether she knew something, she was asked how she knew that her answer to the recognition question was correct. So in both conditions, the model provided perceptual access justifications when asked to explain how she knew something.

In sum, we have demonstrated that a brief modeling intervention caused an immediate improvement in the accuracy of knowledge judgments in a group of older 3- and younger 4-year-olds and in their tendency to justify these judgments in terms of perceptual access. There was no evidence of either of these effects in younger 3-year-olds. We have discussed several mechanisms that may account for these age differences, and it will be important for future research to evaluate these possibilities. Other important questions for future research include whether younger 3-year-olds might benefit were they to receive more extensive modeling, whether modeling has positive effects on other kinds of metacognitive or theory-of-mind judgments, and whether the positive effects generalize beyond the particular judgment or justification that the children observe the model to make.

References

Aguiar, N. R., Stoess, C. J., & Taylor, M. (2012). The development of children's ability to fill gaps in their knowledge by consulting experts. *Child Development, 83*(4), 1368–1381. https://doi.org/10.1111/j.1467-8624.2012.01782.x1.

Amsterlaw, J., & Wellman, H. M. (2006). Theories of mind in transition: A microgenetic study of the development of false belief understanding. *Journal of Cognition and Development, 7*(2), 139–172. https://doi.org/10.1207/s15327647jcd0702_1.

Beck, S. R., McColgan, K. L., Robinson, E. J., & Rowley, M. G. (2011). Imagining what might be: Why children underestimate uncertainty. *Journal of Experimental Child Psychology, 110*, 603–610.

Clements, W. A., Rustin, C. L., & McCallum, S. (2000). Promoting the transition from implicit to explicit understanding: A training study of false belief. *Developmental Science, 3*(1), 81–92. https://doi.org/10.1111/1467-7687.00102.

Fay, A. L., & Klahr, D. (1996). Knowing about guessing and guessing about knowing: Preschoolers' understanding of indeterminacy. *Child Development, 67*(2), 689–716. https://doi.org/10.2307/1131841.

Fisher, M., & Keil, F. C. (2015). The curse of expertise: When more knowledge leads to miscalibrated explanatory insight. *Cognitive Science, 39*(8), 1–19. https://doi.org/10.1111/cogs.12280.

Fritzley, V. H., & Lee, K. (2003). Do young children always say yes to yes–no questions? A metadevelopmental study of the affirmation bias. *Child Development, 74*, 1297–1313. https://doi.org/10.1111/1467-8624.0060.

Gopnik, A., & Graf, P. (1988). Knowing how you know: Young children's ability to identify and remember the sources of their beliefs. *Child Development, 59*, 1366–1371.

Gopnik, A., & Wellman, H. M. (2012). Reconstructing constructivism: Causal models, Bayesian learning mechanisms, and the theory theory. *Psychological Bulletin, 138*, 1085.

Harris, P. L. (1992). From simulation to folk psychology: The case for development. *Mind & Language, 7*, 120–144.

Hembacher, E., & Ghetti, S. (2014). Don't look at my answer: Subjective uncertainty underlies preschoolers' exclusion of their least accurate memories. *Psychological Science, 25*, 1768–1776. https://doi.org/10.1177/0956797614542273.

Hogrefe, G. J., Wimmer, H., & Perner, J. (1986). Ignorance versus false belief: A developmental lag in attribution of epistemic states. *Child Development, 57*, 567–582.

Hülsken, C. (2001). *Training in der Theory of Mind-Forschung: Die Rolle von Kohärenz und Feedback in der Entwicklung einer naiven Alltagspsychologie.* Herzogenrath, Germany: Shaker-Verlag.

Kim, S., Paulus, M., Sodian, B., & Proust, J. (2016). Young children's sensitivity to their own ignorance in informing others. *PLoS One, 11*, e0152595. https://doi.org/10.1371/journal.pone.0152595.

Klahr, D., & Chen, Z. (2003). Overcoming the positive-capture strategy in young children: Learning about indeterminancy. *Child Development, 74*, 1275–1296. https://doi.org/10.1111/1467-8624.00607.

Kloo, D., & Perner, J. (2008). Training theory of mind and executive control: A tool for improving school achievement? *Mind, Brain, and Education, 2*(3), 122–127. https://doi.org/10.1111/j.1751-228X.2008.00042.x.

Kloo, D., Rowher, M., & Perner, J. (2017). Direct and indirect admission of ignorance by children. *Journal of Experimental Child Psychology, 159*, 279–295. https://doi.org/10.1016/j.jecp.2017.02.014.

Koriat, A., & Bjork, R. A. (2005). Illusions of competence in monitoring one's knowledge during study. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 187–194. https://doi.org/10.1037/0278-7393.31.2.187.

Leece, S., Bianco, F., Demicheli, P., & Cavallini, E. (2014). Training preschoolers on first-order false belief understanding: Transfer on advanced ToM skills and metamemory. *Child Development, 85*(6), 2404–2418. https://doi.org/10.1111/cdev.12267.

Lipko, A. R., Dunlosky, J., & Merriman, W. E. (2009). Persistent overconfidence despite practice: The role of task experience in preschoolers' recall predictions. *Journal of Experimental Child Psychology, 103*, 152–166. https://doi.org/10.1016/j.jecp.2008.10.002.

Lipowski, S. L., & Merriman, W. E. (2011). Knowledge judgments and object memory processes in early childhood: Support for the dual criterion account of object nameability judgment. *Journal of Cognition & Development, 12*, 481–501. https://doi.org/10.1080/15248372.2010.544694.

Liu, Y., Su, Y., Xu, G., & Pei, M. (2018). When do you know what you know? The emergence of memory monitoring. *Journal of Experimental Child Psychology, 166*, 34–48. https://doi.org/10.1016/j.jecp.2017.06.014.

Lyons, K. E., & Ghetti, S. (2011). The development of uncertainty monitoring in early childhood. *Child Development, 82*, 1029–1033. https://doi.org/10.1111/j.1467-8624.2011.01649.x.

Marazita, J. M., & Merriman, W. E. (2004). Young children's judgment of whether they know names for objects: The metalinguistic ability it reflects and the processes it involves. *Journal of Memory and Language, 51*(3), 458–472. https://doi.org/10.1016/j.jml.2004.06.008.

Merriman, W. E., Lipko, A. R., & Evey, J. A. (2008). How young children judge whether a word is one they know: A dual criterion account. *Journal of Experimental Child Psychology, 101*, 83–98. https://doi.org/10.1016/j.jecp.2008.06.001.

Moore, C., Bryant, D., & Furrow, D. (1989). Mental terms and the development of certainty. *Child Development, 60*, 167–171. https://doi.org/10.2307/1131082.

Moore, C., Pure, K., & Furrow, D. (1990). Children's understanding of the modal expression of speaker certainty and uncertainty and its relation to the development of a representational theory of mind. *Child Development, 61*, 722–730. https://doi.org/10.2307/1130957.

Moriguchi, Y., Okanda, M., & Itakura, S. (2008). Young children's yes bias: How does it relate to verbal ability, inhibitory control, and theory of mind? *First Language, 28*(4), 431–442. https://doi.org/10.1177/0142723708092413.

O'Neill, D. K., & Chong, S. (2001). Preschool children's difficulty understanding the types of information obtained through the five senses. *Child Development, 72*, 803–815. http://www.jstor.org/stable/1132456.

O'Neill, D. K., & Gopnik, A. (1991). Young children's ability to identify the sources of their beliefs. *Developmental Psychology, 27*(3), 390–397. https://doi.org/10.1037/0012-1649.27.3.390.

Pillow, B. H., Hill, V., Boyce, A., & Stein, C. (2000). Understanding inference as a source of knowledge: Children's ability to evaluate the certainty of deduction,

perception, and guessing. *Developmental Psychology, 36*(2), 169–179. https://doi.org/10.1037/0012-1649.362.169.
Robinson, E. J., Rowley, M. G., Beck, S. R., Carroll, D. J., & Apperly, I. A. (2006). Children's sensitivity to their own relative ignorance: Handling of possibilities under epistemic and physical uncertainty. *Child Development, 77*(6), 1642–1655. https://doi.org/10.1111/j.1467-8624.2006.00964.x.
Rohwer, M., Kloo, D., & Perner, J. (2012). Escape from metaignorance: How children develop an understanding of their own lack of knowledge. *Child Development, 83*(6), 1869–1883. https://doi.org/10.1111/j.1467-8624.2012.01830.x.
Ruffman, T. (1996). Do children understand the mind by means of simulation or a theory? Evidence from their understanding of inference. *Mind & Language, 11*, 388–414. https://doi.org/10.1111/j.1468-0017.1996.tb00053.x.
Schneider, W. (1998). Performance prediction in young children: Effects of skill, metacognition, and wishful thinking. *Developmental Science, 1*(2), 291–297. https://doi.org/10.1111/1467-7687.00044.
Slaughter, V. (1998). Children's understanding of pictorial and mental representations. *Child Development, 69*, 321–332. https://doi.org/10.2307/1132167.
Slaughter, V., & Gopnik, A. (1996). Conceptual coherence in the child's theory of mind: Training children to understand belief. *Child Development, 67*, 2967–2988. https://doi.org/10.2307/1131762.
Sodian, B., & Wimmer, H. (1987). Children's understanding of inference as source of knowledge. *Child Development, 58*, 424–433. https://doi.org/10.2307/1130519.
Wang, Z., Meltzoff, A. N., & Williamson, R. A. (2015). Social learning promotes understanding of the physical world: Preschool children's imitation of weight sorting. *Journal of Experimental Psychology, 136*, 82–91 doi:10.1016.j.jecp.2015.02.010.
Wellman, H. M., & Liu, D. (2004). Scaling of theory-of-mind tasks. *Child Development, 75*, 523–541. https://doi.org/10.2307/1130318.
Williamson, R. A., Jaswal, V. K., & Meltzoff, A. N. (2010). Learning the rules: Observation and imitation of a sorting strategy by 36-month-old children. *Developmental Psychology, 46*, 57–65. https://doi.org/10.1037/a0017473.
Wimmer, H., Hogrefe, G. J., & Perner, J. (1988). Children's understanding of informational access as a source of knowledge. *Child Development, 59*, 386–396. https://doi.org/10.2307/1130318.