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“Model age-based” and “copy when uncertain” biases in children’s social learning of a novel task

Lara A. Wood^a, Rachel A. Harrison^a, Amanda J. Lucas^a, Nicola McGuigan^b, Emily R.R. Burdett^a, Andrew Whiten^{a,*}

^a Centre for Social Learning and Cognitive Evolution, School of Psychology & Neuroscience, University of St Andrews, St Andrews, Fife KY16 9JP, Scotland, UK

^b School of Life Sciences, Heriot-Watt University, Edinburgh EH14 4AS, Scotland, UK

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ABSTRACT

Theoretical models of social learning predict that individuals can benefit from using strategies that specify when and whom to copy. Here the interaction of two social learning strategies, *model age-based biased copying* and *copy when uncertain*, was investigated. Uncertainty was created via a systematic manipulation of demonstration efficacy (completeness) and efficiency (causal relevance of some actions). The participants, 4- to 6-year-old children ($N = 140$), viewed both an adult model and a child model, each of whom used a different tool on a novel task. They did so in a complete condition, a near-complete condition, a partial demonstration condition, or a no-demonstration condition. Half of the demonstrations in each condition incorporated causally irrelevant actions by the models. Social transmission was assessed by first responses but also through children’s continued fidelity, the hallmark of social traditions. Results revealed a bias to copy the child model both on first response and in continued interactions. Demonstration efficacy and efficiency did not affect choice of model at first response but did influence solution exploration across trials, with demonstrations containing causally irrelevant actions decreasing exploration of alternative methods. These results imply that uncertain environments can result in canalized social learning from specific classes of model.

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* Corresponding author.

E-mail address: aw2@st-andrews.ac.uk (A. Whiten).

Introduction

The social learning of behavior, including tool use, language, and cultural norms, is a fundamental aspect of a child's development. However, social information can be outdated or inappropriate. Thus, children do not socially learn indiscriminately; rather, they implement cognitive decision-making rules and social learning strategies (Boyd & Richerson, 1985; Laland, 2004; Rendell et al., 2011). These biases toward certain information or people dictate who young children copy and under what circumstances (Price, Wood, & Whiten, in press; Wood, Kendal, & Flynn, 2013b). Such social learning strategies have the potential to facilitate the creation of social traditions and the evolution of cumulative culture (Dean, Vale, Laland, Flynn, & Kendal, 2014) where cultural traits are modified over multiple generations, resulting in an increase in the complexity and efficiency of these traits. Accordingly, understanding children's selective learning can contribute to our knowledge of uniquely human cultural abilities. The investigation of children's social learning strategies can be achieved through differing experimental paradigms that measure (a) copying choices regarding personal preferences (e.g., Shutts, Kinzler, McKee, & Spelke, 2009), (b) novel object labeling (e.g., Koenig & Harris, 2005), and (c) novel object use (e.g., Wood, Kendal, & Flynn, 2013a). Such empirical methods are used in conjunction with theoretical models predicting that the implementation of social learning strategies dependent on the *context* of the to-be-learned behavior is advantageous (Laland, 2004). Emerging empirical evidence also suggests that children's social learning is often too complex to be explained by a single strategy and that strategies may be most beneficial when they can be used flexibly in different contexts.

“Copy when uncertain” biases

A *copy when uncertain* bias is one social learning strategy dictating when individuals copy others (Rendell et al., 2011). Such a bias has been found in other animal species, including rats (Galef, 2009) and fish (van Bergen, Coolen, & Laland, 2004). The uncertainty in these paradigms may relate to (a) observers' uncertainty regarding their environment and (b) whether they should use social versus personal information. However, their uncertainty can also relate to (c) the efficacy and efficiency of social information and (d) which of multiple sources of information, or “who,” they should best copy. The different paradigms used to investigate children's strategies represent different environments of uncertainty relating to efficacy and efficiency. Novel object labeling paradigms involve two or more models labeling a novel object in divergent ways, but the efficacy of either label remains unknown throughout the paradigm. Novel object use paradigms, such as using a tool to extract a reward from a novel container, differ from such word labeling paradigms in that the efficacy of the model(s) is often made evident by the completion of the task.

These differing contexts of uncertainty influence who gets copied; when model efficacy is uncertain, as when children are presented with a novel object labeled differently by two models, 3- and 4-year-old children use a label provided by a previously proficient word labeler over a previously inept word labeler (Koenig, Clément, & Harris, 2004). Conversely, when efficacy is known, as when children are presented with a novel puzzle that is successfully solved differently by one previously proficient solver and one previously less proficient solver, 5-year-old children do not show an initial preference for either model's method and are motivated to try both methods over time (Wood, Kendal, & Flynn, 2015). Wood, Kendal, and Flynn (2015) argued that because the children were certain about the effectiveness of each method, they did not show any model-based bias to either peer. Similarly, Hu, Buchsbaum, Griffiths, and Xu (2013) found that a bias to follow a majority of others was present only when 3- to 5-year-old children did not know whether the socially demonstrated responses were effective. If children could see that all socially demonstrated responses were effective, the bias was lost. Thus, task-naïve children may implement a model-based bias only when there is some uncertainty as to the efficacy of the social information the models are providing.

Another form of social information uncertainty corresponds to the efficiency of the social information. Models may produce a plethora of behaviors toward a novel task, and understanding

which of those actions are necessary or unnecessary for completing a goal with the object may prove to be important. Likewise, models who perform numerous unnecessary actions may be viewed and copied differently than those who do not. In the domain of social learning research, such causally unnecessary actions have been labeled “irrelevant actions,” and the copying of such actions is commonplace among children and adults (McGuigan, Makinson, & Whiten, 2011). This copying is intriguing and has been argued to enable the development of unique aspects of human culture such as complex cultural practices (Boyd & Richerson, 1996). Although 3- to 5-year-old children often faithfully reproduce such actions, they may nevertheless identify them as “silly” (Wood et al., 2013a) and unnecessary (Lyons, Damrosch, Lin, Macris, & Keil, 2011) and omit them if produced by certain models such as children (Wood, Kendal, & Flynn, 2012). Therefore, there is good reason to think that irrelevant actions might add some ambiguity to the social learning context and children’s perception of model efficiency. A major aim of the current study was to discover whether similar-aged children’s use of a social learning strategy would be affected by the observer’s degree of uncertainty by manipulating the effectiveness and efficiency of the social information provided. The social learning strategy we investigated was a model age-based bias.

“Model age-based” biases

There has been a wave of research demonstrating that young (2- to 6-year-old) children apply *model-based* social learning strategies (Henrich & McElreath, 2003), where there is selective copying dependent on the identity of the model providing the information (Birch, Vauthier, & Bloom, 2008; Corriveau & Harris, 2009a, 2009b; Corriveau et al., 2009; Koenig & Harris, 2005; Lane, Wellman, & Gelman, 2013; McGuigan, 2013; Zmyj, Buttelmann, Carpenter, & Daum, 2010). We chose to investigate a bias for model age because it has been shown to be salient in a number of contexts (Brody & Stoneman, 1981; Jaswal & Neely, 2006; Ryalls, Gul, & Ryalls, 2000; Seehagen & Herbert, 2011; Zmyj, Aschersleben, Prinz, & Daum, 2012), although not always in the same direction. “Vertical” or “oblique” intergenerational transmission where adults are copied rather than children, has been found with videotaped target acts (Seehagen & Herbert, 2011), and novel object labeling (Jaswal & Neely, 2006). Conversely, infants have shown higher fidelity copying of a 3-year-old child versus an adult (Ryalls et al., 2000) and of peers in preference to older children and adults (Zmyj et al., 2012) when the context was play (but see Rakoczy, Hamann, Warneken, & Tomasello, 2010, for children protesting over a puppet that copies a child over an adult). Similarly, 3- to 5-year-olds selected an adult as a model when answering questions within an adult domain, such as the nutritional value of food, but deferred to a child model when the domain was toys (VanderBorghet & Jaswal, 2009).

Establishing traditions

Social learning can be assessed by children’s first responses to a novel object, but sustained social learning, the hallmark of social traditions, measured through continued interaction with that object can give a more detailed picture of social transmission. Wood et al. (2013a) found that 5-year-olds who were previously naive to a puzzle box that could be operated by two different methods became canalized to using just one demonstrated method significantly more than children who had previously explored the box and successfully innovated solutions. Likewise, the presentation of social information before interaction with an object can canalize interactions and limit exploratory play in 4-year-olds (Bonawitz et al., 2011). These results suggest that a copy when uncertain strategy could inhibit innovation and lead to a canalized social tradition. The current study aimed to investigate whether this canalization would happen in relation to a model age-based bias; would uncertainty increase conservatism toward a particular model?

The current study

In this study, we set out to extend our knowledge of 4- to 6-year-old children’s flexible use of social learning strategies by manipulating observer certainty in the efficacy and efficiency of differently aged models. The study employed a puzzle box, the “Slotbox,” which was designed so that each of two

functionally different tools could be used to extract a soft toy. Given mixed findings regarding the direction of model biases for age, we did not make a prediction in this respect. Rather, we aimed to explore the effects of uncertainty on such a bias occurring in either direction. Uncertainty about the efficacy of the social information was created by varying the completeness of the demonstrations such that whereas some children saw both models complete all of the necessary series of actions involved and have a token extracted, others saw a degraded, less complete series of these actions that did not reveal eventual successful removal of the token from a puzzle box task. Uncertainty about the efficiency of the social information was created by varying whether models incorporated visibly causally irrelevant, and thus inefficient, actions into their demonstrations. A final group of children did not witness any social information.

We investigated children's success with a solution method and conservatism to this solution over five response trials. We predicted, first, that children who received social information as compared with the control group would socially learn as indicated by increased success, but that a degraded (vs. full) demonstration would reduce success as measured by latency to success. Second, any model bias would be most pronounced when social information lacked evidence of efficacy and efficiency because the demonstrations would create the most uncertainty. Third, once children have achieved a successful solution, conservatism to this solution would be greatest when they are uncertain of the alternative method. Thus, children who witness two complete and efficient solutions would be predicted to be motivated to explore both demonstrated methods, whereas those with the least complete and inefficient demonstration would be predicted to show more canalization to a particular method.

Method

Participants

In total, 151 4- to 6-year-old children completed the study. Of these, 11 children were excluded from analysis (English not first language [$n = 2$], technical problems during experiment [$n = 6$], or assistance offered by caregiver [$n = 3$]). The remaining 140 children (86 girls) ranged from 4 years (48 months) to 6 years (83 months) of age ($M = 64.1$ months, $SD = 9.9$). Children were recruited while visiting Edinburgh Zoo through a poster that read, "Win stickers. We are interested in children's learning and would like to see how you play with toys we have made." Another poster showed a picture of the Slotbox with "Our toy" written above it. Consent for participation was obtained from children's caregivers provided that they were parents or grandparents. There was no significant difference in the distribution of boys and girls, $\chi^2(6, N = 140) = 0.30, p > .99$, across the seven conditions. There was some difference in the distribution of age, $F(6, 133) = 2.49, p < .05$, across these conditions, but post hoc pairwise comparisons failed to reveal any statistically significant differences ($ps > .05$).

Design

Within each condition, there was a within-group variable of model age (adult or child), with each model demonstrating one of two different methods for reward retrieval (*arrow* or *rake*, counterbalanced and explained further below) sequentially (order of model demonstration was counterbalanced). There were two between-participant variables: (a) demonstration efficacy shown through completeness (three levels: complete, near-complete, or partial) and (b) demonstration efficiency shown through irrelevant actions (two levels: present or absent). Table 1 summarizes the seven six experimental conditions. There was an additional "no-demonstration" control condition that offered no demonstration of any kind; here each model was paired only with a photograph of one of the two tools.

Materials

Video recordings of the models' actions were embedded in PowerPoint presentations shown on two 19-inch monitors on either end of a table facing the child participant. Children were tested in a

Table 1

Overview of experimental conditions.

		Demonstration efficacy (completeness)		
		Partial: Each model held and inserted a tool into the relevant opening of the Slotbox so that it made contact with the token	Near-complete: Same as partial, plus the tool moved the token to the front opening of the box	Complete: Same as near-complete, plus the token was removed from the front opening of the box
Demonstration efficiency (irrelevant actions)	No	Group 1 <i>n</i> = 20	Group 3 <i>n</i> = 20	Group 5 <i>n</i> = 20
	Yes	Group 2 <i>n</i> = 20	Group 4 <i>n</i> = 20	Group 6 <i>n</i> = 20

Note: In addition, there was a no-demonstration group (*n* = 20). Here a picture of an adult model and one tool was shown on one screen and a picture of a child model and the other tool was shown on the opposite screen. No demonstration was shown.

pop-up gazebo within an indoor area of Edinburgh Zoo. Fig. 1 depicts the location of the apparatus within the gazebo. The monitors were each attached to computers out of the child’s view. In the middle of the table lay the Slotbox with the rake and arrow tools. The Slotbox is a largely transparent plastic puzzle box (length = 25 cm, width = 8 cm, maximum height = 14 cm, minimum height = 7 cm) that contained a small soft toy token (a gibbon: height = 10 cm). This token was put in the box through a hole in the top (Fig. 2A) to rest at the back of the box (Fig. 2B). There were two other openings to the box: one at the front (height = 5 cm, width = 6 cm), which was covered by a top-hinged door (with crossbar height = 2 cm, width = 8 cm) that could be lifted up, and a slit (height = 0.5 cm, length = 23 cm) along the side of the box. To the right of the Slotbox on the table were two tools: the rake and the arrow. The rake tool was a long rectangular piece of brown opaque plastic (width = 4 cm,

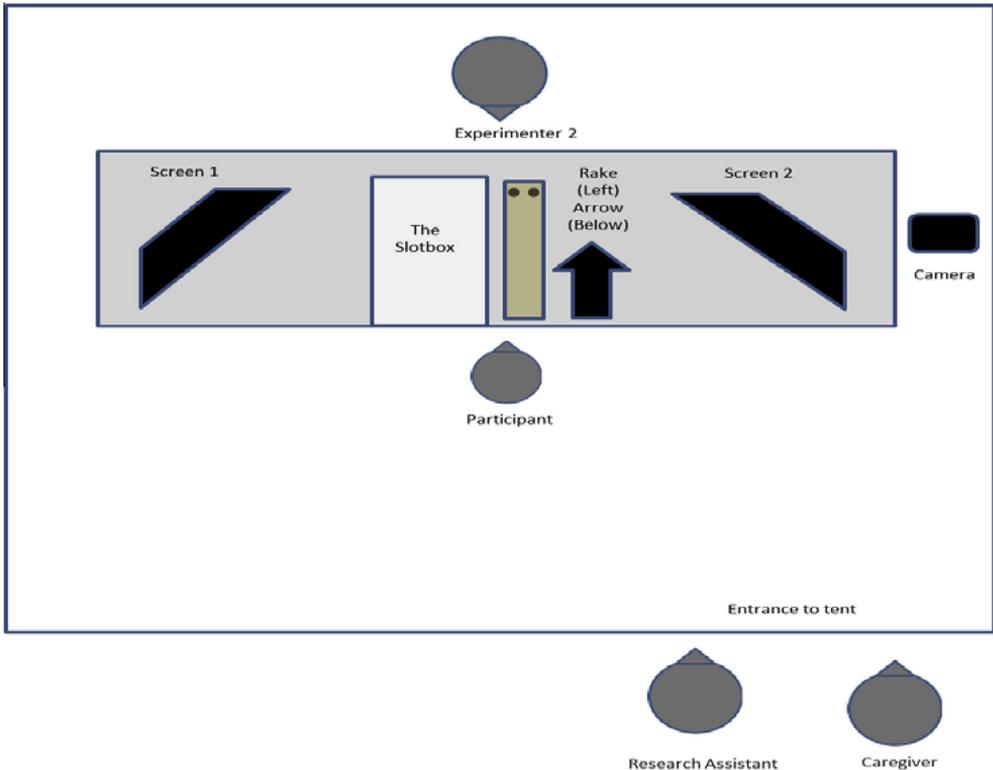


Fig. 1. Bird's-eye view of experimental setup within the gazebo.

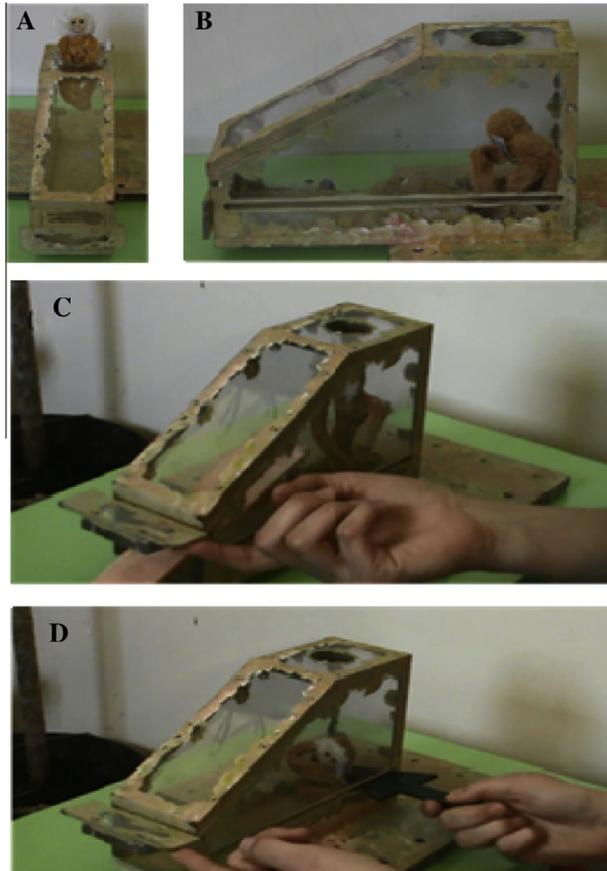


Fig. 2. The Slotbox with video stills showing the following: (A) the token inserted, with front opening guarded by a door; (B) the token-baited Slotbox and slit in the side; (C) the rake tool inserted through the front opening; (D) the arrow tool inserted through the side slit.

length = 25 cm, diameter = 0.2 cm) with three prongs at the end. The arrow tool was a narrow-shaped piece of black plastic (width of arrow base = 10 cm, width of handle = 4 cm, length = 15 cm, diameter = 0.2 cm). Critically, these tools provided two different ways to extract the token. Either the rake could be inserted through the front opening and used to pull the token out of the front opening (Fig. 2C) or, alternatively, the arrow tool could be inserted into the side slit of the box and used to push the token out of the front opening. In addition, a hollow tin with a lid (height = 15 cm, diameter = 10 cm) was used in a warm-up task as well as 2-cm stickers used for rewards.

Models and demonstrations

Three female adults and three female children acted as the models in different videos, so that biases would not be due to characteristics, beyond age, of individual models. These adult and child models were paired for presentations in each of the nine possible combinations. The three adult models were aged 20 to 22 years, and the three child models were aged 4 to 6 years. All models were unfamiliar to the participants and were recorded first looking at the camera and waving.

Initially, an attempt was made to train the child models to perform the demonstration. However, these demonstrations differed significantly from the adult demonstrations in terms of duration,

precision, and clarity. Although this may reflect a naturally occurring difference in competence, it was important to avoid confounding an age bias with a competence bias. Thus, as in Wood et al. (2012), the video demonstrations focused on the task, showing just the model's hands and unclothed arms, and were performed by adults. The "child" demonstration was modeled by a 20-year-old who had small, child-like hands, and the adult demonstration was modeled by a 21-year-old who had average-sized hands, with only the hands and lower arms being visible in the video presentations. No hands had jewelry, nail varnish, or overtly manicured nails. Copies of these video demonstrations are available in the online [Supplementary material](#). In Wood et al. (2012), 20 adults, blind to the study, did not notice that adult and child demonstrations were both performed by adults. In the current study, no child said that the demonstrations were not performed by the model.

Procedure

The research assistant greeted each interested child and caregiver, saying to the child, "Would you like to play a game with some toys and see if you can win some stickers?" The interested party was shown into the gazebo and introduced to the experimenter (E), who was sitting behind the table with the Slotbox (see Fig. 1). The research assistant stood with the parent at the entranceway to the tent.

Photos of the child and the adult models were displayed, one on each monitor. E said, "All of our games today involve getting the Gibbon out of things. It is my turn first." The experimenter used a simple warm-up task to help explain that when the child gets the token out, the child is rewarded with a sticker. E placed the token in a tin and closed the lid, reopened the lid, and took the token out, saying, "That's a sticker for me." She then placed the token back into the tin, closed the lid, and put the tin down on the child's side of the table, saying, "Now it's your turn." Once the child removed the token from the tin, E said, "Well done, that's a sticker for you. Let's start you a pile."

Next, E placed the token into the Slotbox in sight of the child via the hole in the top of the box, saying, "Now we put him in here, and before we start I would like to introduce you to two of my friends. Here is my friend Tina [E points to the first monitor]. Tina is an adult. Can you see her waving?" As this was said, E played a 5-s clip of the model smiling and waving. The same was then done with the second monitor, "Here we have my friend Sophie [E points to the second monitor]. Sophie is a child, the same age as you. Can you see her waving?" Declaring that the child model was "the same age" was done to avoid children assuming that the model was either older or younger. Model introduction order (first or second) and monitor position (left or right) were counterbalanced. Two monitors were used so that there would be a clear distinction between the two models and the two tools.

The following content was dependent on the experimental condition. Children in the no-demonstration condition were told, "Tina and Sophie both played with this, and now it's your turn and you can do anything you like." All other children were told, "Tina and Sophie both played with this, and we are going to watch what they did. Let's watch what Tina, the adult [same order as they were introduced], did when she played with the toy." E then played the video clip twice. Half of the children saw clips in which both of the models performed irrelevant actions. For the rake tool, the irrelevant action was to tap the rake end at the front opening of the slot box four times. For the arrow tool, the flat surface of the tool was slid down the back of the box four times. These actions were performed after the token was inserted and before the relevant action. E then said, "So that is what Tina the adult did. Now let's watch what Sophie, the child, did when she played with the toy." E then played the child clip twice on the other monitor. The end of both clips showed a picture of the model paired with a picture of the tool for the remainder of the experiment. Video clip duration ranged from 12 to 22 s depending on content. The two video clips shown to the same child (one from the adult and one from the child) never differed by more than 4 s.

E recapped by saying, "Now, do you remember that Tina used this tool and Sophie used this tool [E points to appropriate monitors and tools]? Well, now it's your turn and you can do anything you like." The participant was given up to 3 min to interact with the Slotbox. There were a number of set prompts in place if 60 s had elapsed and the child had (a) not yet touched any part of the apparatus ("Can you pick up a tool?"), (b) picked up a tool but not made contact with the Slotbox ("Can you play with the toy?"), or (c) moved the token to the front of the task but not opened door ("You can open the door"). If 2 min had passed and there was no success, the child was asked, "Can you get the toy out?" If

the child had not touched the box after 3 min or if there was no success after 4 min, the child was told that he or she had done very well and the experiment ended. If the child was successful, E said, “Well done, that’s a sticker for your pile. It’s your turn again. You can do whatever you like.” E took a sticker from a pile and added it to the child’s pile and put the token back in the Slotbox. The child was allowed up to five successes. All children were rewarded with six stickers irrespective of success.

Coding and analysis

The second author (R.A.H.) coded 100% of the sample. A research assistant, blind to the study’s aims, coded 60 participants (43%) by watching each video from the moment the experimenter first said, “Now it’s your turn and you can do anything you like.” Each participant’s interaction was coded for successful retrieval of the token (yes or no) and method of success (child demonstrated, adult demonstrated, or alternative) on each of the five trials as well as latency to first success (from “Now it’s your turn and you can do anything you like” to full extraction of the token). There was almost perfect agreement (Viera & Garrett, 2005) on all nominal variables (κ scores $> .97$). Latency to first success had a moderate intraclass correlation of $.54$ ($p < .003$). For within-participant first response and comparisons with the control group, non-parametric tests were used and were two-tailed. Between-participants effects were analyzed using multiple regressions.

Results

Levels of success

Of the 140 children, 122 (87%) were successful at retrieving the token within 3 min. Of these, 60 used the arrow tool and 54 used the rake tool (see below for the other 8), indicating no bias toward either tool ($p = .64$, binomial test). Children who saw a demonstration were significantly more likely to obtain the token than children who did not ($p < .001$, Fisher’s exact test [FET]); fully 116 of 120 children from experimental conditions were successful, whereas 6 of 20 no-demonstration children were successful. From the no-demonstration condition, 1 child used the arrow tool paired with the adult model for five response trials, and the other 5 children put their hand in the front opening and pulled the token out. Thus, they did not use a tool. Only 3 (2.5%) of the other 116 successful children in demonstration conditions initially used their hands rather than a tool to obtain the token; thus, they were significantly less likely to use their hands on the first trial ($p < .001$, FET). These 3 children also used demonstrated tool methods in their other response trials. No children from the no-demonstration condition spontaneously produced one of the two irrelevant actions. Because the no-demonstration group had only 1 child who was successful with a tool, this group was removed from subsequent analysis, as were the four unsuccessful children. The 3 children who were successful with hands were excluded from first trial analysis.

Latency to first success (in seconds) for those who used either demonstrated method was entered into a linear regression with the same predictor variables. Here the prediction model was statistically significant, $F(4, 108) = 7.52$, $p < .001$, and accounted for approximately 22% of the variance of latency to success. Table 2 shows a summary of the predictor variables. Latency to first success was predicted by participant age and demonstration completeness. Older children, and those who saw a more complete demonstration, were more likely to be faster to success. Efficiency and participant sex were not significant predictors.

Model age-based bias

The 113 children who were successful with a tool were more likely to use the tool demonstrated by the child model ($n = 75$, 66%) than the tool demonstrated by the adult model ($n = 38$, 34%) ($p < .001$, binomial test) in their first trial. Of the 116 successful children, 114 completed five trials. Across the five trials, the child method was used more often (median = 3, interquartile range [IQR] = 1.5) than the adult method (median = 2, IQR = 2), $n = 114$, Wilcoxon $Z = -2.53$, $p < .05$. Five children used both

Table 2
Summary of simple regression analyses for variables predicting latency to success (N = 113).

Variable	Latency to success (s)		
	B	SE B	β
Constant	180.88	30.27	
Demonstration efficacy	-20.28	5.05	-.34***
Demonstration efficiency	12.58	8.19	.13
Sex of participant	5.14	8.42	.05
Age of participant (months)	-1.62	0.43	-0.33***
R ²	.22		
F	7.52***		

Note: Demonstration type predictor coded as 1 for partial, 2 for near-complete, and 3 for complete. Irrelevant actions predictor coded as 0 for no and 1 for yes. Sex of participant coded as 0 for male and 1 for female.

*** $p < .001$.

methods simultaneously at some point, all of them after they had used each of the two methods separately.

Irrelevant action reproduction

Although irrelevant action demonstration from the model was a major focus of the current study, irrelevant action reproduction of the participants was not. Thus, here we give a concise description of children’s behavior following demonstrations of irrelevant actions. No children from the no-irrelevant-action conditions produced an irrelevant action, whereas 37 of 60 children (62%) who watched irrelevant actions from both models produced an irrelevant action of some sort on their first trial. Of these, 4 used a hybrid (e.g., tool of the adult, action of the child), 21 performed the irrelevant actions modeled by the child, and 12 performed those modeled by the adult, which was not a difference (binomial $p = .163$).

Efficacy and efficiency

Fig. 3 shows a summary of each child’s first solution method. A logistic regression was run with model copied (adult or child) entered as the dependent variable and demonstration efficacy (completeness), demonstration efficiency (irrelevant actions), and participant sex and age entered as predictor variables. A test of the full model against a constant-only model was not statistically significant, indicating that the predictors did not reliably distinguish between those who used the child model and those who used the adult model, $\chi^2(4, N = 113) = 3.25, p = .51$. None of the independent variables were significant predictors.

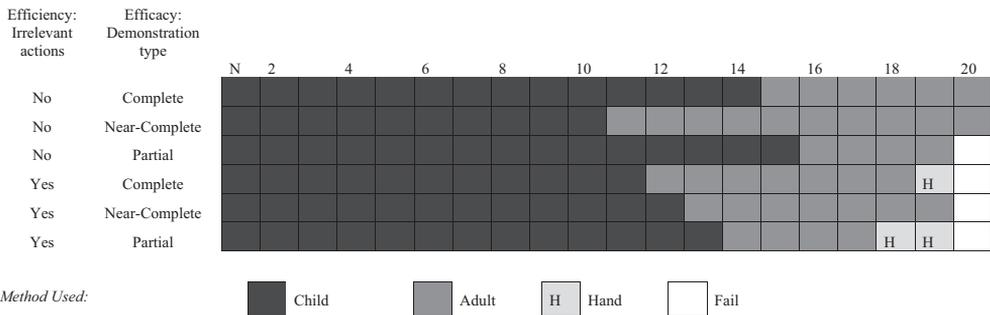


Fig. 3. Overview of each child’s first response.

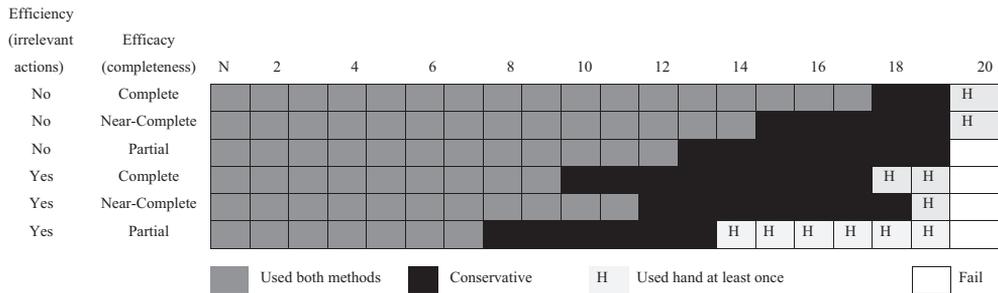


Fig. 4. Responses over five trials relative to whether a child was conservative.

Table 3

Summary of logistic regression analysis for variables predicting number of methods copied.

Predictor	Method conservative (yes or no)		
	B	SE B	e^B
Demonstration efficacy	0.42	0.28	1.52
Demonstration efficiency	-1.08*	0.45	0.34
Trial 1 method	-0.24	0.48	0.79
Sex of participant	-0.72	0.48	0.49
Age of participant (months)	-0.05*	0.02	1.05
Constant	-2.37		
χ^2	12.05*		
df	5		
% Conservative	30.1		

Note: e^B , exponentiated B. Demonstration efficacy (completeness) predictor coded as 1 for partial, 2 for near-complete, and 3 for complete. Efficacy (irrelevant action) predictor coded as 0 for no and 1 for yes. Trial 1 method coded as 0 for child and 1 for adult. Sex of participant coded as 0 for male and 1 for female.

* $p < .05$.

Conservatism

The final analysis investigated children's conservatism to an initial solution. There were an unanticipated 11 children who used their hands to remove the token on at least one trial (including 3 children who did this on their first trial). These 11 children and the 4 who were initially unsuccessful were removed, leaving a total of 105 children (see Fig. 4). A logistic regression was run with method conservatism (yes or no) entered as the dependent variable and efficacy, efficiency, model choice on first trial, and participant sex and age entered as predictor variables. A test of the full model against a constant-only model was statistically significant, indicating that the predictors as a set reliably distinguished between children who copied just one model and children who copied both models (see Table 3). Efficacy, participant sex, and first method were not significant predictors. Age was a significant predictor, with increasing age predicting decreased likelihood of conservatism. Efficiency was a significant predictor, with inefficient demonstrations increasing the likelihood of conservatism. Whereas only 29 of 57 children (51%) who saw an irrelevant action displayed both methods, 45 of 59 children (76%) who did not see an irrelevant action showed both methods ($p < .01$, FET).

Discussion

We tested for a model age-based bias in differing contexts by examining children's first solution choice and also their conservatism in relation to this first solution over five response trials. Our first prediction that children would socially learn from the information provided was supported; children with no demonstration were generally unsuccessful. Context had some effect; demonstration

completeness significantly predicted latency to success, with children in the partial condition taking longer to solve the task than children who received more complete information. This would indicate that these children found retrieving the token to be harder yet possible, even with limited information within the demonstrations.

We did not make a specific prediction regarding the direction of model biases for age. Our results showed that children tended to preferentially copy the child model both on their first response trial and over time. The use of similar two-action reward retrieval tasks has elicited some variant biases in previous studies; when similar-aged children were shown *either* an adult *or* a child demonstrating relevant and irrelevant actions, they were more faithful in their copying of the adult (McGuigan et al., 2011; Wood et al., 2012). However, a bias toward copying peer models has been found when the context was less goal directed and more overtly playful (Ryalls et al., 2000; Zmyj et al., 2012). We presented the Slotbox overtly as a playful game-like activity, and children appeared correspondingly to treat it as such by copying the child over the adult. Furthermore, the device used in Wood et al. (2012) and McGuigan et al. (2011) was much less transparently a toy for which a child would have privileged knowledge, whereas the Slotbox was called a toy, and given that 3- to 5-year-olds are known to select children over adults when the domain is toys (VanderBorghet & Jaswal, 2009), this labeling could have created the preference for a child model.

Our second prediction, that the model age-based bias would be most pronounced when social information lacked evidence of efficacy and efficiency because the demonstrations would create the most uncertainty, was not supported. Neither efficacy (demonstration completeness) nor efficiency (irrelevant actions) affected the strength of the initial model-based bias toward child peers. The presence of the model age-based bias, when both models gave demonstrations, varies from Wood et al. (2015), who found that children did not distinguish between two peers who differed in previous proficiency when two equally valid solutions were demonstrated. One explanation for this could be that the age contrast in the current study may be considerably more salient than the peer proficiency contrast in Wood et al. (2015) study. For the latter, the models differed in their general levels of proficiency, as indexed by their behavior toward a novel apparatus as well as teacher ratings. This subtler difference between models may have diluted children's attention to proficiency in the context of the test task. Indeed, the peer ratings of proficiency in Wood et al. (2015) were dominated by age, such that children rated older peers as more proficient than younger peers irrespective of their actual proficiency. Furthermore, previous work has shown that even though children can identify models who "know" versus "don't know" how to do a task, their imitation of the model is driven more by their age than by their professed knowledge state (Wood et al., 2012). An alternative explanation for the current finding is that the preference for matching the child model, irrespective of demonstration content, was driven by affiliative reasons rather than learning reasons (Uzgiris, 1981). If children copy to affiliate, then it is of no consequence which method is more effective. Affiliative versus learning goals may explain the discrepancy between the current study and Hu et al. (2013), who found that a bias toward copying the majority was lost when children could see that both methods worked. This "second" function of imitation is receiving increasing attention (Over & Carpenter, 2012; Wood et al., 2013b) and may be an important factor in children's model-based social learning choices.

Our third prediction, that conservatism to the initial solution would be greatest when children are uncertain of the alternative method, was partly supported. Children's continued interaction with the task revealed behavior differences across conditions. Specifically, children who viewed both models using irrelevant actions were significantly less likely to use both methods than children who viewed both models using relevant-only actions. One possible explanation for why demonstrated irrelevant actions discouraged use of the alternate method is that participants may have had more uncertainty about the quality and competence of the demonstrations offered and so continued to use their initial previous solution and were reluctant to try the alternative method. Conversely, when there was a lack of irrelevant actions (and potentially more information regarding success), this led to confidence in both models and, thus, exploration beyond children's initial bias and personal success. The current results support the hypothesis that a copy when uncertain bias could promote conservatism to an original method and, thus, inhibit exploration of an alternative method, as found with Wood et al. (2013a) and Bonawitz et al. (2011).

There was an additional result that was not specifically predicted; the select few children with no demonstration who were successful tended not to use a tool, instead—more efficiently perhaps—using their hand. This result again highlights both the advantage and cost of using social information; demonstration children were much more likely to be successful but also more likely to use a tool that was actually unnecessary (cf. Nielsen & Tomaselli, 2010). We take this as further evidence that when children have no prior information, social information can promote high-fidelity copying of demonstrated actions (Wood et al., 2013a) to the point of copying inefficient components (McGuigan et al., 2007). It would be interesting to investigate what the children with social demonstrations would have done if the tools were removed during their response; would they have been even less likely to succeed than children with no social demonstrations because they were reliant on the social information of using a tool for success?

Children's biases in social learning identified in this study are likely to have wider implications for our understanding of social traditions. In the current study, the most likely context in which a solution was socially learned and persisted over time was when it was performed by a child and when the information was constrained (incomplete) and inefficient. Thus, incipient traditions in the kind of context created in our experiment may be more likely to form when there is limited scope for confidence in the approaches seen in models and there are biases toward learning from individuals (in this case children) with certain characteristics. Conversely, confidence in the quality of competing socially demonstrated solutions may promote motivation for further exploration of alternative approaches witnessed. A combination of social learning and exploration is thought to be the bedrock of cumulative culture; thus, seeing multiple effective solutions from multiple models may be an influential component in humans' cumulative cultural capacities.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.jecp.2016.06.005>.

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