

The Development of Selective Copying:

Children's Learning from an Expert versus their Mother

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Abstract

This study tested the prediction that, with age, children should rely less on familiarity and more on expertise in their selective social learning. Experiment 1 (N=50) found that 5- to 6-year-olds copied the technique their mother used to extract a prize from a novel puzzle box, in preference to both a stranger and an established expert. This bias occurred despite children acknowledging the expert model's superior capability. Experiment 2 (N=50) demonstrated a shift in 7-to 8-year-olds towards copying the expert. Children aged 9- to 10-years did not copy according to a model bias. The findings of a follow-up study (N=30) confirmed that, instead, they prioritized their own – partially flawed – causal understanding of the puzzle box.

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A rich wave of research over the past decade into the development of selective social learning has found that young children display a range of cognitive biases disposing them towards learning new information from the most competent and culturally appropriate models in their social spheres (Harris, 2012; Koenig & Sabbagh, 2013). There is now a growing interest in evaluating this body of new work in relation to the broader topic of the evolution of culture (Chudek, Muthukrishna, & Henrich, 2015; Harris & Corriveau, 2011; Henrich & Broesch, 2011; Whiten, Hinde, Laland, & Stringer, 2011). The field of cultural evolution offers an explanatory framework for understanding both how human cognition evolved to facilitate the acquisition of complex culture, and the population-level consequences of selective learning biases that shape how culture is transmitted over successive generations. The newer developmental research is beginning to offer empirical evaluation of more longstanding theoretical models of cultural evolution. For instance, experimental support has been provided for predictions that individuals should learn selectively from others according to such factors as model competence, age, prestige, consensus and familiarity (Chudek, Heller, Birch, & Henrich, 2012; Harris & Corriveau, 2011; Morgan, Laland, & Harris, 2015).

Regarding the latter bias – familiarity – there is debate in the cultural evolution literature concerning the extent to which culture is predominately transferred ‘vertically’ from parents or ‘horizontally/obliquely’ from other non-family adults or peers (see Hewlett, Fouts, Boyette, & Hewlett, 2011; Mesoudi, 2009). Early models of cultural transmission make different population level predictions based upon which mode of transmission is most influential. Cavalli-Sforza and Feldman (1981) developed mathematical models indicating that vertical transmission leads to highly conserved pockets of culture, whilst oblique or horizontal transmission leads to the rapid spread of new practices and beliefs. Subsequent

empirical evidence for the two types of proliferation is mixed. Interview-based psychological and anthropological studies generally support the case for vertical transmission (e.g., Cavalli-Sforza, Feldman, Chen, & Dornbusch, 1982; Hewlett & Cavalli-Sforza, 1986), as individuals tend retrospectively to say that they learned their skills, beliefs and habits predominantly from their parents. However, modeling by McElreath and Strimling (2008) concluded that vertical transmission is adaptive only in times of environmental stability (i.e., when behaviors do not need to adapt to changing circumstances), and more recent observational and experimental approaches in small scale societies find some evidence in favor of oblique and horizontal transmission (Henrich & Broesch, 2011; Hewlett et al., 2011).

In an attempt to reconcile these conflicting lines of evidence, Henrich and Broesch (2011) postulate a two-stage theory of transmission. They hypothesize that children should initially learn from their parents. At this stage of life they possess low skill levels that do not require the input of specialist expertise. Parents are therefore the most appropriate models, since they are 'low-cost' (to the child) and willing to invest large amounts of time in teaching and scaffolding a range of fundamental skills. As children get older they are more likely to benefit from honing these basic skills by learning preferentially from non-family members according to model biases – for example, favoring those who are deemed to be particularly competent or prestigious. This two-stage theory may explain the discrepancy between interview-based findings (favoring vertical transmission) and experimental findings (favoring oblique and horizontal transmission), as individuals might initially learn a particular skill from their parents, but later refine their proficiency by observing experts in the community. If they learned 80% of a skill (e.g., how to use a bow and arrow) from their parents and 20% from an expert, they are perhaps likely to say, when interviewed, that they learned the skill from their parents – overlooking the role of experts in their learning (Henrich & Broesch, 2011).

Evidence from experimental studies of children's learning from testimony offers strong support for an initial vertical learning preference in young children. Given a forced choice, preschoolers endorse new information provided by their familiar caregivers (i.e. their mothers or preschool teachers) above that provided by strangers (Corriveau et al., 2009; Corriveau & Harris, 2009). Tellingly, however, this preference seems to shift in importance throughout development. If children witness their familiar teacher provide inaccurate information (e.g., incorrectly labeling familiar objects) whilst an unfamiliar teacher provides accurate information (e.g., correctly labeling familiar objects) they respond differently according to their age. Three-year-olds ignore their teacher's previous inaccuracy and continue to endorse her testimony when learning the name of a novel object. Five-year-olds, in contrast, place their trust in the previously accurate stranger (Corriveau & Harris, 2009). This age-related change suggests that children move beyond an initial socio-emotional pull to trust familiar caregivers and begin to place more value on indicators of competence that may help them to distinguish reliable sources of information amongst non-family members (Harris & Corriveau, 2011). Indeed, Corriveau et al. (2009) also found that an initial preference, in 5-year-olds, for learning words from their mother rather than a stranger was reversed (in securely attached children at least) if their mother provided an improbable answer.

The findings of Corriveau, Harris and colleagues lend initial support to Henrich and Broesch's (2011) two-stage theory, as they suggest that children's preference for learning from their familiar caregivers becomes more discriminating with age. This work provides interesting insights into how young children respond to the inaccuracies of their familiar caregivers. However it does not tell us about the weighting that children place on familiarity versus expertise per se. This was the focus of the present study. We examined children's preference for learning from their mother versus an expert, when their mother was not

explicitly shown to be wrong. Thus, rather than emphasizing to children the inaccuracy of their caregiver, we instead emphasized the expertise of the stranger.

In this sense, the present experiment echoes, to some extent, those in which infants have been shown to be sensitive to the expertise of an experimenter in laboratory settings. These studies are consistent in demonstrating that infants are more likely to visually reference an experimenter than their mother when presented with an ambiguous toy (Kim & Kwak, 2011; Walden & Kim, 2005 – for review see Harris & Lane, 2014). They also proceed to play with such a toy for longer if an experimenter encourages them to do so, than if their mother does the same (Stenberg, 2009). Such findings hint at a precocious understanding in infants that an experimenter is the local ‘expert’ in unfamiliar settings (Harris & Lane, 2014). Whether or not this anticipates young children’s actual copying of the actions or skills of an expert, rather than their mother, is a question addressed in the current study.

Experiment 1

In Experiment 1, we tested whom children would preferentially copy - their mother or a stranger - when trying to extract a prize from a puzzle box. There were two between-subject conditions: Mother vs. Stranger and Mother vs. Expert. The Mother vs. Stranger condition was designed to provide a baseline level of children’s preference for copying their mother. Comparing this to the Mother vs. Expert condition would then enable evaluation of the relative weighting that children place on expertise. The chosen age range of the participants was 5- to 6-years, as this is the age at which existing studies (Corriveau & Harris, 2009; Corriveau et al., 2009) find children become more discerning in their selective learning from their caregivers’ testimony. In line with Corriveau et al., we predicted that children would prefer to learn from their mother in the Mother vs. Stranger condition. Of interest was whether this preference would shift in the Mother vs. Expert condition.

Model Biases for Learning Actions: Considerations and a Further Prediction

The vast majority of selective social learning experiments have been conducted in the domain of word learning, whereby one informant provides one novel label, and another informant provides an alternative novel label, for an unfamiliar object. In these circumstances children cannot possibly work out the answer for themselves, as object labels are arbitrary and socially constructed. Very few equivalent studies have been conducted in the domain of imitation and the copying of causal actions. In such experiments, children observe different models performing alternative actions to achieve the same goal (Hu, Buchsbaum, Griffiths, & Xu, 2013; Wood, Kendal, & Flynn, 2015). These studies are fundamentally different from those that test word-learning, in that it is possible for children to integrate their own causal understanding with the information they gain socially, in order to achieve the end goal (see Hu et al., 2013, for a discussion). Indeed, both Hu et al. (2013) and Wood et al. (2015) demonstrate that model biases are reduced (or lost altogether) when children are provided with more causal information about the task.

The present study sought to elicit a high reliance on social learning from one model or the other (and a low reliance on personal learning) by employing a causally opaque puzzle box task. Children could not see into the puzzle box, so they could not observe the causal mechanisms connecting the two alternative actions (demonstrated by the models) to the releasing of the prize. To gauge the strength of children's reliance on social learning, we also measured how many times children implemented their chosen action on the puzzle box. Both models – mother and stranger/expert – performed their particular action twice in succession (i.e., more times than was actually necessary to release the prize). If children are faithful in their copying of these two complete actions, then this will indicate strong social learning. If, however, they copy less than twice, then this might indicate a more personal stance – whereby children integrate their causal understanding that repeating the action is not necessary to release the prize. Because (a) the causal relations between the actions and the

outcome in the current task were deliberately opaque and (b) children have been shown to 'overimitate' even obviously causally inefficient actions (Horner & Whiten, 2005; Lyons, Damrosch, Lin, Macris, & Keil, 2011), we predicted that children in the present experiment would show strong social learning and copy their chosen action twice.

Method

Participants

Fifty 5- to 6-year-olds and their mothers were recruited whilst visiting Edinburgh Zoo, Scotland. Twenty-five were assigned to the Mother vs. Stranger condition (9 female; age range 60-83 months; mean 72.6) and twenty-five to the Mother vs. Expert condition (14 female; age range 60-83 months; mean 70.48). The participants were 98% British and predominantly ethnically White. All children spoke English as a first language. Note that the decision to restrict participant selection to mothers (rather than fathers or grandparents who also accompany children to Edinburgh Zoo) was in order to make the current findings comparable with previous research that has focused on mothers (though Henrich and Broesch's (2011) prediction would suggest a similar pattern of results for any closely related caregiver).

Materials

A children's table and two chairs were set up in front of a 23-inch monitor that was connected to a laptop. The screen was used to display: (a) A simple children's video game that was operated using a mouse. The game had background music that children listened to using headphones. This served as a distraction while the child's mother was being trained in how to operate the test puzzle box; (b) Short video clips of two models attempting to obtain prizes from three different puzzle boxes (see Table 1 and Supplementary Electronic Materials). The purpose of these clips was to establish the expertise of 'Jenny' (an

experimenter). Jenny was successful at obtaining prizes from all three puzzle boxes. In contrast, another unknown female model was unsuccessful.

Two puzzle boxes – a ‘practice’ puzzle box and a ‘test’ puzzle box – were employed. The practice puzzle box can be seen in Figure 1a. A reward (a hollow egg containing a sticker) was pushed into the box through a tube on the side and there were two alternative methods that could be attempted to release it. One method – the ‘Handle’ – was non-functional. The other method – the ‘Flap’ – was functional in ejecting the prize. When the reward was released it landed in an opaque, red, prize receptacle. Children needed to open the lid of this receptacle in order to discover whether or not they had been successful. The test puzzle box (adapted from Wood, Kendal, & Flynn, 2015) can be seen in Figure 1b. A reward was dropped into the box through a pipe on the top and there were two alternative methods that could be attempted to release it. Both of these methods – the ‘Slide’ and the ‘Trapdoor’ – were functional in ejecting the prize. As with the practice box, when the reward was released it landed in an opaque, red, prize receptacle. In this case, the receptacle was secured with a padlock that needed to be opened by the experimenter before children could discover whether or not they had been successful. (See Supplementary Electronic Materials for a video showing the operation of the test puzzle box.)

Procedure

The testing took place in a gazebo erected in the Budongo Visitors’ Centre of Edinburgh Zoo. The Mother vs. Stranger procedure is first described below, followed by an explanation of how this differed in the Mother vs. Expert condition.

Mother vs. Stranger condition.

Distraction task and training of mother. Each child was invited to take part in a distraction task with Experimenter 1 (E1). The task was a moderately noisy video game, for which the child was required to wear headphones. While the child was distracted, his or her

mother was trained out of sight by E2 in how to perform one of the two alternative actions on the puzzle box (either the Slide or the Trapdoor). This training involved both learning what to say ('Oh, I've seen one of these before. I think you do this to get the prize out') and the action, which was to be repeated twice. Thus, for the Slide, the mother was taught to slide a handle back and forth two times. For the Trapdoor, she was taught to pull a lever in and out two times. 'Jenny' (an experimenter who acted either as the stranger or the expert) was present for this training. She and the mother took turns in practicing the method that they had been assigned and delivering their utterance. This gave the mother the opportunity to match Jenny (as far as possible) in intonation and confidence.

Practice puzzle box. The practice box served two purposes. First, it illustrated to the child that the reward needed to be moved from the main puzzle box into the red prize receptacle. Second, it demonstrated that only one of the two attempted actions was the correct one for releasing the prize. It was hoped that this would signal that it was possible to perform an incorrect action and *not* win the prize. This, in turn, might place implicit pressure on the child to choose the 'correct' action when operating the subsequent test puzzle box.

E1 brought the distraction task to a close and explained to the child that it was now time to look at some puzzle boxes. E2 entered the test area and brought out the training box saying, 'Here is the first puzzle box. It's quite funny looking isn't it? This is what we do with it.' She then showed the child a plastic egg that contained a sticker. 'I have a special egg with a sticker inside. To win the sticker the egg goes inside and you need to get it out of the puzzle box (points to the main body of the puzzle box) and into the red box (points to the red prize receptacle). Now there is only one way that works. Why don't you try this way first (points to Handle)? Pull it out. Okay, now have a look in the red box and see if you got the egg? No? Well that way doesn't work. Let's try a different way. Try moving this flap here (motions to the Flap). Okay, now have a look in the red box and see if you got the egg.

Yes! Well done! You have won a sticker!' E2 removed the sticker from the egg and gave it to the child.

Test puzzle box. E2 brought out the test puzzle box and said, 'It's another funny looking one isn't it? Our boss only gave us this puzzle box today. We know the egg goes in the top here. But we don't know how to get it out, do we?' E2 then looked to E1, who shook her head and put her hands up in confusion. E2 continued, 'And this time you only get one turn at trying to win the sticker. Mmmm...I wonder if somebody could show us what to do?' E2 then asked E1 if she would go out into the zoo and look for someone who might be able to show them how to get the prize out. E1 agreed and exited the testing area for approximately 10 seconds. She returned with Jenny (who was wearing a coat and carrying a bag) saying, 'I've found someone who says they would like to look at the puzzle box. This is Jenny. She is here visiting the zoo today'. E2 replied, 'Hello Jenny. Nice to meet you. We are trying to learn how to get a prize out of this puzzle box'. Jenny then demonstrated one of the two actions on the puzzle box while saying, 'Oh, I have seen one of these before. I think you do this to get the prize out.' As Jenny was shown out of the test area E1 said, 'There is also another person who says they will look at the puzzle box. I will just go and get them'. She soon returned with the child's mother saying, 'Here is the other person who says they will take a look at the puzzle box. It is [child's name's] mum'. E2 said, 'Hello [child's name's] mum. We are trying to learn how to get a prize out of this puzzle box'. The mother demonstrated the other of the two actions on the puzzle box whilst delivering the same utterance as Jenny (i.e., 'Oh, I have seen one of these before. I think you do this to get the prize out'). She was then shown out of the test area. The order in which Jenny and the Mother were brought into the testing area was counterbalanced. In addition, the actions assigned to the Mother and Jenny (Slide or Trapdoor) and the order in which these actions were presented (Slide first or Trapdoor first) were also counterbalanced.

In the final testing stage, E2 placed an egg (with a sticker inside) into the puzzle box and invited the child to try and get it out. When the child had finished manipulating the puzzle box, E2 noted which action he or she performed and the number of times it was completed, before asking two questions. The first was to ascertain the child's reason for choosing the method he or she used; the second was intended to assess the child's understanding of which model was more proficient. Thus E2 said, 'Just before we open the red box to find out if you got the egg, can you tell me why you chose to do it this way (motioning to the action that the child had used)?' After the child had given their answer, E2 said, 'And who do you thinking is better at getting prizes out of puzzle boxes? Is it Jenny – the lady that was just here – or your Mum?' (The order of mention of Jenny and the Mother was counterbalanced).

The experiment was brought to a close by E2 unlocking the red prize receptacle and allowing the child to retrieve the egg with the sticker inside it. Children who had not copied their mother's method were invited to try the puzzle box again using her method (with an empty egg) to demonstrate that both methods actually worked. The purpose of this was to ensure that children did not leave the experiment believing that their mother had shown them something that was 'wrong'.

Mother vs. Expert condition. The procedure for the Mother vs. Expert condition was the same as for the Mother vs. Stranger condition except that there was an extra stage in which children were familiarized to the expertise of Jenny. This occurred after the distraction task and before children were introduced to the puzzle boxes. Children were introduced to Jenny and told that she was 'very good at getting prizes out of puzzle boxes'. They then viewed three short videos in which Jenny successfully retrieved prizes out of three different puzzle boxes. This was in comparison to another unknown person in a yellow shirt, who was not successful. The purpose of including the unsuccessful person was to emphasize Jenny's

expertise. After the child had viewed both Jenny's and the unknown person's attempt on a particular puzzle box, he or she was asked, 'Who got the prize out of the puzzle box? Was it Jenny or the lady in yellow? (The order of mention of Jenny and the lady in yellow was counterbalanced; all children answered these questions correctly). When all three videos had been viewed, E2 said, 'So you can see that Jenny really is good at getting prizes out of puzzle boxes.' At this point in the procedure Jenny's mobile phone rang and she excused herself to take the call. The experiment then proceeded in exactly the same way as the Mother vs. Stranger condition, except for two small changes. The first was that Jenny was not wearing a coat or carrying a bag. This was because, in this condition, she was not intended to look like a visitor to the zoo. The second was the wording that E1 used when she re-introduced Jenny. Instead of saying that Jenny was 'visiting the zoo' she simply said, 'I found Jenny outside. She would like to look at the puzzle box'.

Results

Preliminary analysis revealed no significant differences in children's responses according to Age, Gender, Method (i.e., whether the Mother demonstrated the Slide or the Trapdoor method) or Model Order (i.e. whether the Mother performed her demonstration before or after Jenny). These factors are not therefore included in the subsequent analyses, which are presented in four sections. The first examines which model (mother or Jenny) children copied. The second describes children's response to the forced-choice question, 'Who do you think is better at getting prizes out of puzzle boxes? Is it your Mum, or is it Jenny?' The third reports how many times children completed their chosen action on the puzzle box. The fourth section explores children's responses to the question, 'Why did you choose *this way* to get the prize out of the puzzle box?'

A small number of children (Mother vs. Stranger condition = 2; Mother vs. Expert condition = 1) attempted to reproduce both methods on the puzzle box (i.e., both the Slide

and the Trapdoor). These three children are not included in the subsequent analyses because it was not possible (a) to ascertain whether they copied their mother or Jenny; (b) to record how many times they completed their chosen action, because they did not choose one single action; and (c) to ascertain why they completed their chosen action, as they did not choose one single action.

Whom Did Children Copy?

In the Mother vs. Stranger condition, 19 children copied their mother and 5 copied Jenny (Binomial, $p < .01$). In the Mother vs. Expert condition, 17 children copied their mother and 6 copied Jenny (Binomial, $p < .03$). Thus, the number of children who copied their mother was significantly higher than the number expected by chance in both conditions. There was no significant difference in the proportion of children who copied their mother between the two conditions ($p = .74$, two-tailed Fisher's Exact test).

Whom Did Children Say Were 'Better'?

Children's responses to the forced-choice question, 'Who is better at getting prizes out of puzzle boxes? Is it your Mum or Jenny?' were split into three categories: Mother, Jenny and Other. The category of 'Other' included children who: (a) did not answer, (b) shrugged their shoulders, or (c) gave an alternative reply (such as saying that they themselves were better at getting prizes out of puzzle boxes). (Note that children who made an Other response were not further encouraged to make a selection, as it was possible that their reserve was due to them not wanting to explicitly say that someone other than their mother was 'better'.) In the Mother vs. Stranger condition, 16 children said their mother was 'better', 4 said Jenny was 'better' and 4 gave a response that was categorized as Other. In the Mother vs. Expert condition 3 children said their mother was 'better', 12 said Jenny was 'better' and 8 gave an Other response. A Chi square test of independence revealed a significant difference in response between the two conditions, whereby fewer children said that their mother was

better in the Mother vs. Expert condition than in the Mother vs. Stranger condition: $X^2(2, N = 47) = 14.21, p < .001$.

Figure 2 illustrates the percentage of children who copied their mother and the percentage who said she was 'better' in each of the two conditions. In order to examine whether individual children changed their responses between the two types of trial, they were categorized as follows: In the Mother vs. Stranger condition, 14 children both copied their mother and said she was 'better'; 5 copied their mother, but did not say she was 'better'; 2 did not copy their mother, but said she was 'better' and 3 did not copy their mother and did not say she was 'better'. A McNemar test was non-significant ($\chi^2(1, N = 24) = 0.57, p = .45$), indicating that children tended to make the same response for whom they copied and whom they said was 'better'. In the Mother vs. Expert condition, 2 children both copied their mother and said she was 'better'; 15 copied their mother, but did not say she was 'better'; 1 did not copy his mother, but said she was 'better' and 5 did not copy their mother and did not say she was 'better'. A McNemar test revealed a significant shift in response between the two types of trial ($\chi^2(1, N = 23) = 10.56, p = .001$), indicating that children who copied their mother tended not to say that she was 'better'.

How Many Completions Did Children Make?

For the Slide action, one full completion was defined as the handle being moved along the length of the puzzle box towards the child and then back again to its original position. For the Trapdoor action, one full completion was defined as the lever being pulled out and then pushed back in again. If children did not make a full completion – for example, if they moved the handle only towards themselves and not back again (for the Slide), or if they pulled out the lever, but did not push it back (for the Trapdoor) this was counted as half. The mean number of full completions made by children was 2.18 (SD 0.43) and 1.99 (SD 0.41) in the Mother vs. Stranger and Mother vs. Expert conditions respectively, and 2.11 (SD

0.29) and 2.01 (SD 1.01), according to whether they copied their mother or Jenny. A two-way analysis of variance (ANOVA) was conducted with Number of Completions as the dependent variable. The between-participant factors were Condition (Mother vs. Stranger, Mother vs. Expert) and Who Was Copied (Mother, Jenny). This analysis revealed no reliable main effect and no significant interaction ($F(3, 43) = 0.04, p = .99$). Children witnessed two full completions of each demonstrated action and the overall mean number that they reproduced was 2.10 (SD 1.66). Thus, children were, on average – across conditions and regardless of which model they copied – faithful in terms of the number of times they copied.

Why Did Children Say they performed their Chosen Action?

Children's responses to the question probing why they chose the action that they performed were coded into five categories: Model, Causal, Better, Uninformative and Don't Know. The category of 'Model' was used when children said that they had chosen their action because they had copied one of the models (either their mother or Jenny). Example responses included, 'Cos my mum showed me', 'Because I like my mum's idea more' and 'We were watching Jenny (i.e., opening puzzle boxes on video)'. Explanations were coded as 'Causal' when children provided a physical reason explaining why their chosen method would release the prize. Examples included, 'It might push harder than the other one', 'Cos the egg will slide along and go into the red box' and 'Because you have to pull to make it go down'. The category of 'Better' was used when children described their preferred method as somehow easier to perform or better than the other without saying why: 'It would be easier', 'A good way I thought'. Responses were coded as 'Uninformative' if they did not provide any information about a particular method. For instance, 'To get it into the red box', 'Cos I did', and 'It might get it'. Finally, children who either said nothing or said that they didn't know why they chose their particular action were coded as 'Don't Know'. The number of children providing responses in each of these five categories can be seen in Table 2.

Collapsing across the two conditions, only a relatively small number of children (23%) explicitly said that they copied a model. The most common response (34% of children) was Causal. Indeed, over half of those children who provided an informative response (disregarding those in the Don't Know and Uninformative categories) generated a causal explanation for why their chosen method was effective.

Discussion

We examined 5- to 6-year-olds' preferential copying of their mother versus a previously unknown female adult, when trying to learn how to release a prize from a puzzle box. In the Mother vs. Stranger condition, children received no history regarding the unknown female's proficiency at opening puzzle boxes. In the Mother vs. Expert condition, children were told that the previously unknown female was 'very good at getting prizes out of puzzle boxes' and were shown video evidence confirming that this was the case. As predicted, in the former condition, it was found that children displayed a strong preference for copying the method demonstrated to them by their mother. This result concurs with Corriveau et al. (2009), suggesting that children's preference for learning from their mother generalizes from the domain of language acquisition to the domain of copying skills and actions. It also provides further verification of Henrich and Broesch's (2011) prediction of an initial vertical learning bias in young children.

Of interest was whether this bias for learning from their mother would shift when children were given information about a stranger's expertise. Such a switch, however, did not occur. Children copied their mother's method of opening the puzzle box, despite being provided with evidence of the unknown female adult's prowess. They did this at exactly the same rate as in the Mother vs. Stranger condition, suggesting that expertise has no impact on 5- to 6-year-old children's preferential copying of their mother. This finding stands in contrast to the discrimination that 5-year-olds seemed to show when learning words from

their familiar caregivers (Corriveau et al., 2009; Corriveau & Harris, 2009). Unlike those studies, the mothers in the current experiment did not provide any incorrect information (or demonstrate incompetence). This may suggest that children of this age are mistrustful of learning from their mothers only when their mothers are explicitly shown to be wrong.

A possible explanation for children's seeming lack of sensitivity to expertise in the present experiment is that they failed to generalize the proficiency that the expert model demonstrated in the video clips as relevant to the operation of the real-life puzzle box. However, a recent experiment suggests that children do indeed make this generalization. Burdett et al., (2015) employed the same type of video clips as in the present study – whereby one unknown female was successful, and another was unsuccessful, at retrieving prizes from a selection of puzzle boxes. In test trials utilizing the same test puzzle box as the current experiment, children preferred to copy the previously successful model as compared to the model who was unsuccessful. This finding would strongly suggest that difficulty in extrapolating expertise was not the cause of children's failure to copy the expert in the present experiment.

Moreover, children's responses to the question, 'Who was better at getting prizes out of puzzle boxes?' confirms their comprehension of the successful model's expertise. Despite demonstrating a strong bias for copying their mother, children did not tend to go on to say that she was 'better'. Instead they either said that Jenny was better or they did not indicate either model. In contrast, children who copied their mother in the Mother vs. Stranger condition tended to also say that she was better at getting prizes out of puzzle boxes. The former result suggests a gap between what children understand about relative expertise and their actual behavior. Such disparities are not uncommon in developmental experiments. For instance, Robinson and Whitcombe (2003) found that preschoolers perform well in a procedural test of source monitoring skills, despite performing poorly on an equivalent

explicit measure. It is usually the case, however, that children display an implicit understanding *before* they possess the corresponding explicit, or verbally expressed, comprehension. The present result appears to reveal the opposite effect. Children demonstrate an explicit understanding that their mother is not the most qualified model, yet their behavior implies that they nevertheless regard her to be the best person to copy. This inconsistency may be an indication that a cognitive understanding of expertise is not the only driver of children's selective copying. Indeed, Corriveau et al. (2009) found that preschoolers' preferential learning from their mother varies with their attachment style. Thus, it may be that children's socio-emotional motivation to copy their mother trumps their intellectual understanding that she is not always the most competent.

A further example of a discrepancy between children's explicit understanding (as indexed by what they say) and implicit comprehension (as indexed by their behavior) is illustrated in their replies to why they chose their particular action. Only a minority demonstrated explicit awareness that their behavior was motivated by a model bias. Yet the strong preference that the group displayed for copying their mother clearly demonstrates its influence. Overall the most common response was for children to generate a causal explanation for why their chosen action was preferred. This finding might suggest that children were not consciously aware of the social learning strategy underlying their choice of method and that – on a post-hoc basis – they generated a physical reason for it. This fits with the adult literature demonstrating that individuals are poor at introspecting on their cognitive processes and instead confabulate, constructing plausible causal justifications for why they make particular decisions (Nisbett & Wilson, 1977). Indeed, the finding that children were, on average, faithful in copying two completions of their chosen action is further evidence that they adopted a social, rather than a causal, approach. Recall that it was not necessary to make two full completions to release the prize. Thus, if children had truly chosen their particular

method because they had reasoned about how it might physically work, then it might be expected that they would copy their chosen action less than twice.

Overall, Experiment 1 found that children aged 5- to 6-years demonstrate a strong bias towards copying their mothers, despite being explicitly aware of a stranger's superior expertise. It seems likely that such a bias is socio-emotionally motivated. Presumably, if Henrich and Broesch (2011) are correct, children's explicit reasoning about expertise should, with development, outweigh the sway of attachment. Experiment 2 aimed to explore whether such a switch – from copying Mother to copying Expert – might take place, with age.

Experiment 2

The aim of Experiment 2 was to explore the effect of age on children's copying preferences when presented with their mother versus an expert. Thus the present experiment repeated the Mother vs. Expert condition of Experiment 1, with children aged 7- to 10-years.

Method

Participants

Twenty-five 7- to 8-year-olds (10 female; age range 84-107 months; mean 96.25) and twenty-five 9- to 10-year-olds (16 female; age range 108-131 months; mean 119.65) and their mothers were recruited whilst visiting Edinburgh Zoo, Scotland. The participants were 96% British and predominantly ethnically White. All children spoke English as a first language.

Materials and Procedure

The experimental materials and protocol were exactly the same as for the Mother vs. Expert condition of Experiment 1.

Results

Preliminary analysis revealed no significant differences in children's responses according to Gender or Model Order. These factors are not therefore included in the subsequent analyses, which are presented in the same format as Experiment 1. There was,

however, an effect of Method, whereby children in the oldest age group demonstrated an overwhelming bias towards the Slide (as compared to the Trapdoor). This effect will be presented and further examined in the final sections of the analyses.

In order to test for effects of age throughout, the results of Experiment 1 (twenty-five 5-to 6-year-olds, Mother vs. Expert condition) and Experiment 2 (twenty-five 7-to 8-year-olds and twenty-five 9- to 10-year-olds) were combined, resulting in a sample size of seventy-five. Eight children (two 5- to 6-year-olds, three 7- to 8-year-olds, three 9- to 10-year-olds) who attempted to copy both methods on the puzzle box (i.e., both the Slide and the Trapdoor) are not included in the analyses for the reasons set out in Experiment 1.

Whom Did Children Copy?

A Chi square test of independence revealed a significant difference in the proportion of children copying their mother across the three age groups: $X^2(2, N = 67) = 6.42, p = .04$ (see Figure 3). Further analysis revealed that this was driven by a difference between 5- to 6-years (copy mother: copy expert; 17:6) and 7- to 8-years (copy mother: copy expert; 8:14), indicating a switch away from copying the mother and towards copying the expert ($p = .02$, Fisher's Exact test). However, the number of children copying the expert did not differ from chance for either the 7- to 8-year-olds (copy mother: copy expert; 8:14, Binomial, $p = .29$) or the 9- to 10-year-olds (copy mother: copy expert; 12:10, Binomial, $p = .83$).

Whom Did Children Say Were 'Better'?

Children's responses to the forced-choice question, 'Who is better at getting prizes out of puzzle boxes? Is it your Mum or Jenny?' were split into three categories: Mother, Expert and Other. Of the 5- to 6-year-olds (Experiment 1, Mother vs. Expert condition) 3 children said their mother was 'better', 12 said the Expert was 'better' and 8 gave an Other response. Of the 7- to 8-year-olds, none said their mother was 'better', 12 said the Expert was 'better' and 10 made a response categorized as Other. Of the 9- to 10-year-olds, 3

children said their mother was 'better', 15 said the Expert was 'better' and 4 made an Other response. A Chi Square test of independence confirmed that there was no significant difference in response across the age groups: $X^2(4, N = 67) = 6.04, p = .20$, demonstrating that similarly few children, of all ages, said that their mother was 'better'.

How Many Completions Did Children Make?

The mean number of full completions (with standard deviations) made by children in each age group were: 5- to 6-years (Experiment 1, Mother vs. Expert condition) = 2.02 (1.56), 7- to 8-years = 1.91 (1.48), 9- to 10-years = 1.05 (.53). A one-way ANOVA conducted with Number of Completions as the dependent measure and Age (5- to 6-years, 7- to 8-years, 9- to 10-years) as the between-participant factor revealed a reliable difference among the age groups, $F(2, 64) = 3.87, p = .03, \eta^2 = .11$. Post hoc (Tukey-Kramer) comparisons revealed that the 9- to 10-year-olds made fewer completions than the 5- to 6-year-olds. The number of completions made by the 7- to 8-year-olds did not differ from the 5- to 6-year-olds, but approached significance in differing from the 9- to 10-year-olds. Figure 4 depicts the means for the three age groups with 95% confidence intervals.

Why Did Children Say they Performed their Chosen Action?

The number of children providing responses in each of the five categories (Model, Causal, Better, Uninformative and Don't Know) can be seen in Table 2. Consistent with the results from the 5- to 6-year-olds, only a relatively small number of children aged 7- to 10-years said that they copied a model. Again, the most common response was Causal. It was not possible to conduct meaningful non-parametric analyses examining age differences on these data (because expected frequencies for some categories were less than 5). However, arithmetically, the tendency to provide a causal explanation increased with age. At age 5- to 6-years (Experiment 1, Mother vs. Expert condition) 26% of responses were Causal, whereas the figure was 50% for 7- to 8-year-olds, and 68% for 9- to 10-year-olds.

Were the Slide and the Trapdoor Chosen Equally Often?

Because the model – mother or expert – performing either the Slide or the Trapdoor was counterbalanced, it should be expected (if there was no prior preference for either the Slide or the Trapdoor), that an equal number of children should select one or the other of these two actions. Of the 5- to 6-year-olds (Experiment 1, Mother vs. Expert condition), 14 used the Slide and 9 used the Trapdoor (Binomial, $p = .40$). Of the 7- to 8-year-olds, 15 used the Slide and 7 used the Trapdoor (Binomial, $p = .13$). However among the 9- to 10-year-olds, 22 used the Slide and none used the Trapdoor (Binomial, $p < .001$). Thus, the Slide was used more often than would be expected by chance by the 9- to 10-year-olds only. A Chi Square test of independence revealed a significant difference in the proportion of children using the Slide across the three age groups: $X^2(2, N = 67) = 10.61, p < .001$ (see Figure 3). Further analysis confirmed that this was driven by a difference between 7- to 8-years and 9- to 10-years ($p < .01$, two-tailed Fisher's Exact test).

Post-Hoc Analysis

Although the proportion of 7- to 8-year-olds using the Slide versus the Trapdoor did not represent a statistically significant preference, the ratio of 15:7 was nevertheless not entirely convincing of a chance distribution. This might suggest that a bias for the Slide method, detected in the 9- to 10-year-olds, gradually emerged with age. To investigate this possibility we examined children of 7- versus 8-years separately and found that for 7-year-olds, 7 used the Slide and 5 used the Trapdoor (Binomial, $p = .77$), whereas for 8-year-olds the proportion was 8:2 (Binomial, $p = .11$). Interestingly, if we also look at the number of children who copied their mother versus the expert separately for 7- and 8 year-olds, we find that the ratio is 2:10 (copy mother: copy expert) for 7-year-olds (Binomial, $p = .04$) and 6:4 for 8-year-olds (Binomial, $p = .75$). Thus, 7-year-olds are at chance in their use of the Slide versus the Trapdoor, and copy the expert more often than would be expected by chance.

Eight-year-olds, in contrast, approach significance in their use of the Slide versus the Trapdoor and perform at chance in their copying of their mother versus the expert.

Discussion

In Experiment 2 we aimed to discover the age at which children might switch from copying their mother to copying a previously unknown female with demonstrable expertise. We found that 7- to 8-year-old children copied their mothers significantly less than 5- to 6-year-olds. However, this apparent developmental switch towards the expert was not realized in the oldest children. Nine- to ten-year-olds performed at chance in copying their mother versus the expert. Moreover, almost without exception, they favored use of the Slide (over the Trapdoor) for releasing the prize from the puzzle box. Like the younger children, nearly all of them acknowledged that their mother was not the best qualified model. Thus, it would seem that older children's understanding of expertise was outweighed by their 'Slide bias'.

This finding of a Slide bias in the oldest children renders the result from the 7- to 8-year-olds difficult to interpret. Did they copy their mother less than the 5- to 6-year-olds because they valued expertise more heavily, or because they showed the beginnings of the Slide bias? Two pieces of evidence suggest that children in this age group (the youngest members at least) did genuinely switch towards the expert. The first comes from post-hoc analysis examining 7- and 8-year-olds separately. The former showed no evidence of favoring the Slide and they copied the expert model above chance. Indeed, 83% of 7-year-olds copied the expert. In contrast, 8-year-olds performed at chance in their copying of their mother versus the expert and showed a tentative indication of the Slide bias. This would suggest a brief window at age seven where children copied the expert, before a preference for the Slide began to override this effect. The second piece of evidence comes from the finding that the oldest children made fewer completions of their chosen action than the younger children. Nine- to ten year-olds made an average of just one completion of the twice-

demonstrated action – presumably indicating their understanding that two completions were not necessary to release the prize. In contrast, the younger age groups made an average of two completions – suggesting their high reliance on social learning, without such causal reasoning. This further suggests that the switch in the 7- to 8-year-olds was truly towards the expert, since they, like the 5- to 6-year-olds seemed to be taking a social, and not a causal, stance.

Follow Up Study

As outlined in the introduction, goal-orientated, causal action tasks may be particularly vulnerable to the rejection of social learning strategies (Hu et al., 2013). Unlike the learning of language (in which most selective trust research has been conducted) and social conventions, it is possible to attempt to find a solution to causal tasks individually. Taken together, the findings of Experiments 1 and 2 suggest that the oldest children were taking a fundamentally different approach from the younger, whereby they placed less weight on social information and more on their own personal or causal understanding. Why, however, should these older children exhibit such a strong preference for the Slide method?

To answer this question, a small follow up study was conducted ($N = 30$; 15 six- to seven year-olds and 15 nine- to ten-year-olds; see Electronic Supplementary Materials for full information) with the purpose of (a) replicating the Slide bias in older children and (b) questioning both younger and older children about the causal effectiveness of the Slide and the Trapdoor method. In this study, children were not given demonstrations from two models. Rather, the experimenter demonstrated each of the two possible methods (in a counterbalanced order) before questioning children about their causal efficacy.

When asked which method they were going to choose, children in both age groups (younger group 12 out of 15, $p < .04$, Binomial; older group 13 out of 15, $p < .001$, Binomial) stated that they were going to select the Slide. Furthermore, nearly all of these children were

able to provide an adequate causal explanation for how the Slide might work to release the egg (younger group 10 of 12; older group 13 of 13). These explanations generally tended to involve an understanding that the Slide mechanism would push the egg along the length of the puzzle box and down into the red prize receptacle. In contrast, only a small minority of older children (younger group 0 of 15; older group 3 of 15) were able to adequately explain how the Trapdoor might work – e.g., ‘It would work if it pulls out a platform, it might drop the egg down’. Indeed, many children struggled to imagine how the ‘pulling’ mechanism of the Trapdoor could move the egg in the right direction, saying for example, ‘Will only pull it, it wouldn’t push it’; ‘You pull it, and if you pull it, it won’t end up over there’. After questioning, when children were finally invited to attempt to retrieve the egg from the puzzle box, nearly all of them (younger group 14 of 15, $p < .001$, Binomial; older group 13 of 15, $p < .001$, Binomial) used the Slide.

Thus, it would seem that children found the Slide method more causally plausible than the Trapdoor. Surprisingly, this bias for the Slide method was just as strong in the younger children as in the older children. This clarifies our interpretation of the findings of Experiment 2, suggesting not that children’s emerging Slide bias began to override their willingness to learn from a particular model, but rather that children, with age, began to prioritize a pre-existing preference for the Slide method, above social learning.

In Experiment 2, it was found that, although younger children were, on average, faithful in reproducing two full completions of their chosen action, the oldest children reproduced only one. This effect was lost in the follow-up study, wherein both age groups repeated the action less than twice: younger group mean 1.33; older group mean 0.93 (standard deviations 0.91 and 0.53 respectively; no significant difference between age groups $t(28) = 1.47, p = .15$). This may not be surprising, however, as children were asked to reflect upon how the two mechanisms may or may not work *before* performing their action. That is,

they were explicitly encouraged to think causally. This may have (a) *led them to the understanding* that two completions were not necessary to eject the prize or (b) led them to take a 'causal stance' whereby they *demonstrated their understanding* that two completions were not necessary to eject the prize. Either way, this finding supports the contention that the younger children in Experiments 1 and 2 were taking a 'social stance', rather than a 'causal stance', as indexed by their faithful copying of either their mother or the expert.

General Discussion

Experiment 1 showed that children aged 5- to 6-years, when attempting to learn how to release a prize from a novel puzzle box, preferred to copy their mother over both a stranger and an established expert. This preference occurred despite children acknowledging the expert model's superior capability, suggesting that children's explicit understanding of who is best qualified does not necessarily drive their copying behavior. Experiment 2 demonstrated that 7- to 8-year-olds switched away from copying their mother and towards copying the expert. This age group's strong social learning stance (as indexed by their faithful copying of two completed actions), as well as the finding that nearly all 7-year-olds copied the action that the expert demonstrated, is highly suggestive that this switch was driven by the increased weighting that children placed on expertise. These results together broadly support the hypothesis of Henrich and Broesch (2011), who predicted that an initial preference for learning from familiar caregivers should, with development, give way to a preference for learning from strangers – favoring model biases for competence or expertise.

For children aged 9- to 10-years, our finding of a 'Slide bias' suggests that children of this age did not use a social learning strategy when deciding how to release the prize from the puzzle box. Instead, they preferred to rely on their own causal understanding or naïve physics to reason that the Slide was a more plausible method than the Trapdoor. This shift from a social, to a personal, learning strategy is further underlined by the finding that the

oldest children made fewer completions of their chosen method than the younger children – presumably indicating their causal understanding that extra completions were superfluous to the goal of the task.

An alternative explanation for older children making fewer completions could be that they were simply less motivated by the puzzle-box (and the reward) than younger children and so interacted with the task less. We cannot absolutely rule out this interpretation, but the finding that younger children in the follow-up study also performed fewer than two completions (after being explicitly encouraged to reason causally about the puzzle-box) does add support to the contention that making fewer completions is a valid indication of children taking a 'causal stance' to the task.

An Adaptive Developmental Trajectory?

It is tempting to interpret the shift revealed in the current study, from a social stance in younger children, to a causal stance in older children, in terms of an adaptive developmental trajectory – see Figure 3. Stages 1 and 2, in line with Henrich and Broesch (2011), may represent the predicted transition from an initial bias for learning from familiar caregivers towards learning from an expert. Stage 3 might suggest a further phase, not predicted by Henrich and Broesch. Here, once children perceive themselves to have an adequate causal understanding of a task, they rely on their own skill or knowledge, rather than deferring to others. Such a strategy may be adaptive in that it prevents children from being led astray by social learning. Rather than accepting all socially transmitted information at face value, children first check whether the information fits with their pre-existing knowledge (Harris, 2012, Chapter 2; Harris, 2002). This may allow children to construct increasingly robust schemas and knowledge bases, rather than starting 'from scratch' with each isolated instance of social learning.

We must, however, be cautious about over-interpreting the current data. A more parsimonious construal may be that children make use of three different heuristics – (1) copy mother, (2) copy expert, (3) use own causal knowledge – and that these may unfold at different ages (and even in a different order) according to the transparency of the causal mechanism in question, and according to contextual cues. Consider, for example, a recent study which found that children aged 7-11 years were more likely, with age, to defer to expert testimony that contradicted their naïve physics (Symons, Tolmie & Oaksford, 2015). This would seem to be the reverse of current findings. Symons et al.'s task required children to reason about the contributory effects of three different variables on a continuous measurement (how far a car would travel). The current task, in contrast, is perhaps more binary, in that children are required to reason about whether a mechanical action is likely to move a reward in the right direction or not. Thus, it may be that as children mature they make more, not less, use of social learning heuristics, at least for tasks where the possible causal relations between the start and end state are more uncertain. Furthermore, it may be possible to manipulate the experimental context so that even very young children (in line with findings on selective attention in infants, reviewed in the introduction) favor learning from an expert rather than from their mother. Relevant manipulations might be that the test item is presented as belonging to the expert or that the test location is clearly associated with the expert (e.g., a doctor's surgery or mechanic's workshop). Future research should thus be directed towards manipulating the complexity and transparency of causal tasks, as well as experimental contexts, in order to identify how these relate to the relative unfolding of the three learning heuristics identified in his experiment.

Overconfidence in One's Own Judgments?

The discussion so far has assumed older children's neglect of social learning to be an intelligent response, indicating their mastery of a task. However, it should be borne in mind

that the older children in the current experiment were not correct in their assumption that the Slide method was the superior option for releasing the prize from the puzzle box. The Trapdoor was an equally viable and functional solution, advocated (for fifty percent of the time) by an established expert. Many artifacts in human culture that children must make sense of are causally opaque. Therefore, is it really sensible, or adaptive, to ignore an expert who demonstrates a perfectly valid method, in favor of an option that children view as more physically plausible?

Overconfidence in one's own judgments, as indexed by the rejection of advice from others, is an effect that has been robustly demonstrated in adults (Soll & Mannes, 2011; Yaniv & Kleinberger, 2000). Young children, in contrast, seem especially willing to update their own initial guesses on the basis of testimony from others (Rakoczy, Ehrling, Harris, & Schultze, 2015; Robinson & Whitcombe, 2003). However a recent study finds that they become increasingly reluctant to do so with age (Morgan et al., 2015). This phenomenon is of interest to theorists of cultural evolution because experimental studies with adults find that many participants make far less use of social information than mathematical models (describing the evolution of optimal social information use) would predict (Efferson et al., 2007; Eriksson & Strimling, 2009; Mesoudi, 2011). Erikson and Strimling offer several explanations for this counterintuitive bias – including (a) that individuals may gain more 'cognitive rewards' from working out a solution for themselves, and (b) that humans may have a general tendency to generate personal solutions as part of a cooperative, 'anti-freeloading' propensity for contributing to new knowledge. Examining the emergence of a possible bias in children to favor their own, rather than others' solutions, may help distinguish between these possible motivations and their implications for the effective transmission of culture.

Future Directions for Research on Selective Trust in Familiar Caregivers

The current study contributes to a small portfolio of research on the topic of selective learning from familiar caregivers, with the finding that, with age, children's preference for copying their mother shifts towards copying an expert – supporting the evolutionary predictions of Henrich and Broesch (2011). In modern societies, however, children's first introduction to an 'expert' is unlikely to be in the fashion that Henrich and Broesch envisage, whereby, for example, hunter-gatherer children hone their skill with a bow and arrow by seeking out the most successful hunters in the community. Rather, the first 'expert' in modern (especially Western) children's lives is almost always a school teacher. Teachers exist in children's lives, not as peripheral members of their community, but as familiar caregivers themselves (especially for preschoolers). It will be important for future research to examine how children shift from learning from familiar caregivers, to unfamiliar experts, through the transitional stage of learning from caregivers who are teachers.

Conclusion

An abundance of studies over the past ten years has revealed potent effects of selectivity in children's social learning. Few selective learning experiments, however, have been conducted with: (a) goal orientated action tasks or (b) children above the age of seven years. The current findings suggest that these may be fertile areas of research, enabling examination of the relative weighting that children place on their personal causal understanding versus their learning from others, how this changes over time, and whether such changes are adaptive in terms of cultural evolutionary theory.

References

- Chudek, M., Muthukrishna, M., & Henrich, J. (2015). Cultural evolution. In D. M. Buss (Ed.), *The handbook of evolutionary psychology* (749-769). New York: John Wiley & Sons.
- Burdett E. R. R., Lucas, A. J., Buchsbaum, D., McGuigan, N., Wood, L. A., & Whiten, A. Copy the expert or the crowd? Children's selective trust in learning instrumental and normative skills. Presented at the Society for Research in Child Development (SRCD), Philadelphia, USA, March, 2015.
- Cavalli-Sforza, L., Feldman, M., Chen, K., & Dornbusch, S. (1982). Theory and observation in cultural transmission. *Science*, *218*(4567), 19–27. doi:10.1126/science.7123211
- Cavalli-Sforza, L. L., & Feldman, M. W. (1981). *Cultural transmission and evolution*. Princeton, NJ: Princeton University.
- Chudek, M., Heller, S., Birch, S., & Henrich, J. (2012). Prestige-biased cultural learning: bystander's differential attention to potential models influences children's learning. *Evolution and Human Behavior*, *33*(1), 46–56. doi:10.1016/j.evolhumbehav.2011.05.005
- Corriveau, K. H., Harris, P. L., Meins, E., Fernyhough, C., Arnott, B., Elliott, L., ... de Rosnay, M. (2009). Young children's trust in their mother's claims: longitudinal links with attachment security in infancy. *Child Development*, *80*(3), 750–61. doi:10.1111/j.1467-8624.2009.01295.x
- Corriveau, K., & Harris, P. L. (2009). Choosing your informant: weighing familiarity and recent accuracy. *Developmental Science*, *12*(3), 426–437.
- Efferson, C., Richerson, P. J., McElreath, R., Lubell, M., Edsten, E., Waring, T. M., ... Baum, W. (2007). Learning, productivity, and noise: an experimental study of cultural transmission on the Bolivian Altiplano. *Evolution and Human Behavior*, *28*(1), 11–17. doi:10.1016/j.evolhumbehav.2006.05.005













- Eriksson, K., & Strimling, P. (2009). Biases for acquiring information individually rather than socially. *Journal of Evolutionary Psychology*, 7(4), 309–329.
doi:10.1556/JEP.7.2009.4.4
- Harris, P. L. (2002). Checking our sources : the origins of trust in testimony. *Studies In History and Philosophy of Science*, 33, 315–333.
- Harris, P. L. (2012). *Trusting What You're Told: How Children Learn From Others*. Cambridge, MA: Harvard University Press.
- Harris, P. L., & Corriveau, K. H. (2011). Young children's selective trust in informants. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 366(1567), 1179–87. doi:10.1098/rstb.2010.0321
- Harris, P. L., & Lane, J. D. (2014). Infants understand how testimony works. *Topoi*, 33(2), 443–458. doi:10.1007/s11245-013-9180-0
- Henrich, J., & Broesch, J. (2011). On the nature of cultural transmission networks: evidence from Fijian villages for adaptive learning biases. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 366(1567), 1139–48.
doi:10.1098/rstb.2010.0323
- Hewlett, B. S., & Cavalli-Sforza, L. L. (1986). Cultural transmission among aka pygmies. *American Anthropologist*, 88(4), 922–934. doi:10.1525/aa.1986.88.4.02a00100
- Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 366(1567), 1168–78. doi:10.1098/rstb.2010.0373
- Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition*, 8(3), 164–81. doi:10.1007/s10071-004-0239-6

- Hu, J. C., Buchsbaum, D., & Griffiths, T. L. When does the majority rule? Preschoolers' trust in majority informants varies by domain. Proceedings of the 35th annual meeting of the Cognitive Science Society, Berlin, Germany, August, 2013.
- Kim, G., & Kwak, K. (2011). Uncertainty Matters: Impact of Stimulus Ambiguity on Infant Social Referencing. *Infant and Child Development*, 463, 449–463. doi:10.1002/icd
- Koenig, M. A., & Sabbagh, M. A. (2013). Selective social learning: New perspectives on learning from others. *Developmental Psychology*, 49(3), 399–403.
doi:10.1037/a0031619
- Lyons, D. E., Damrosch, D. H., Lin, J. K., Macris, D. M., & Keil, F. C. (2011). The scope and limits of overimitation in the transmission of artefact culture. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 366(1567), 1158–67. doi:10.1098/rstb.2010.0335
- McElreath, R., & Strimling, P. (2008). When natural selection favors imitation of parents. *Current Anthropology*, 49(2), 307–316. doi:10.1086/524364
- Mesoudi, A. (2009). How cultural evolutionary theory can inform social psychology and vice versa. *Psychological Review*, 116(4), 929–952. doi:10.1037/a0017062
- Mesoudi, A. (2011). An experimental comparison of human social learning strategies: payoff-biased social learning is adaptive but underused. *Evolution and Human Behavior*, 32(5), 334–342. doi:10.1016/j.evolhumbehav.2010.12.001
- Morgan, T. J. H., Laland, K. N., & Harris, P. L. (2015). The development of adaptive conformity in young children: effects of uncertainty and consensus. *Developmental Science*, 18(4), 511–24. doi:10.1111/desc.12231
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: verbal reports on mental processes. *Psychological Review*, 84(3), 231–259.

- Rakoczy, H., Ehrling, C., Harris, P. L., & Schultze, T. (2015). Young children heed advice selectively. *Journal of Experimental Child Psychology, 138*, 71–87.
doi:10.1016/j.jecp.2015.04.007
- Robinson, E. J., & Whitcombe, E. L. (2003). Children's suggestibility in relation to their understanding about sources of knowledge. *Child Development, 74*(1), 48–62.
doi:10.1111/1467-8624.t01-1-00520
- Soll, J. B., & Mannes, A. E. (2011). Judgmental aggregation strategies depend on whether the self is involved. *International Journal of Forecasting, 27*(1), 81–102.
doi:10.1016/j.ijforecast.2010.05.003
- Stenberg, G. (2009). Selectivity in Infant Social Referencing. *Infancy, 14*(4).
doi:10.1080/15250000902994115
- Symons, G., Tolmie, A., & Oaksford, M. Source Reliability in the Development of Children's Understanding of Causal Systems. Proceedings of the EuroAsianPacific Joint Conference on Cognitive Science, Torino, Italy, September, 2015.
- Walden, T., & Kim, G. (2005). Infants' social looking toward mothers and strangers. *International Journal of Behavioral Development, 29*(5), 356–360.
- Whiten, A., Hinde, R. A., Laland, K. N., & Stringer, C. B. (2011). Culture Evolves. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 366*(1567), 938–48. doi:10.1098/rstb.2010.0372
- Wood, L. A., Kendal, R. L., & Flynn, E. G. (2015). Does a peer model's task proficiency influence children's solution choice and innovation? *Journal of Experimental Child Psychology, 139*, 190–202.
- Yaniv, I., & Kleinberger, E. (2000). Advice taking in decision making: egocentric discounting and reputation formation. *Organizational Behavior and Human Decision Processes, 83*(2), 260–281. doi:10.1006/obhd.2000.2909

Table 1

Video Clips used to Establish Expertise in the Mother vs. Expert Condition

	Expert		Inexpert	
Clip	Opening scene	Closing Scene	Opening Scene	Closing Scene
Clip 1				
	The blue and red counters are rotated (using the center dial) from the top corners of the board to the bottom center track. They are then pushed down the track and off the board to reveal two toy animals hidden under them.		The blue counter is rotated (using the center dial) from the top left corner into the bottom left corner. It is then rotated to the top right corner where it is pushed up against the red counter.	
Clip 2				
	The yellow counter is placed on top of the peg on the yellow circle. The top layer is then rotated to reveal a toy rabbit hidden in the second layer.		The top layer is manipulated, but will not rotate because the yellow counter blocks it. The yellow counter is then placed into the opposite hole (still blocking the top layer) followed by another unsuccessful attempt at rotation.	
Clip 3				
	The middle and bottom blue shelves are pulled out in turn, allowing a toy cow to drop down from the center portion of the tower and out of the bottom doorway.		The green pyramids are lifted and inspected, revealing no toy animals. The lid of the tower is then lifted and the top portion of the tower inspected, again revealing no toy animals.	

These video clips are available to view in the Supplementary Electronic Material

Table 2

Number of Children Providing Responses in each of Five Categories when Asked 'Why' they performed their Chosen Action (Experiments 1 & 2)

	Model	Causal	Better	Uninform	Don't Know	Total
Mother vs. Stranger						
5- to 6-years	6	10	1	3	4	24
Mother vs. Expert						
5- to 6-years	5	6	2	5	5	23
7- to 8-years	3	11	0	1	7	22
9- to 10-years	3	15	0	2	2	22

Note that the totals for each age group are slightly less than the sample sizes of 25, as they do not include children who attempted both demonstrated methods

Figure 1

Practice Puzzle Box (a) and Test Puzzle Box (b)

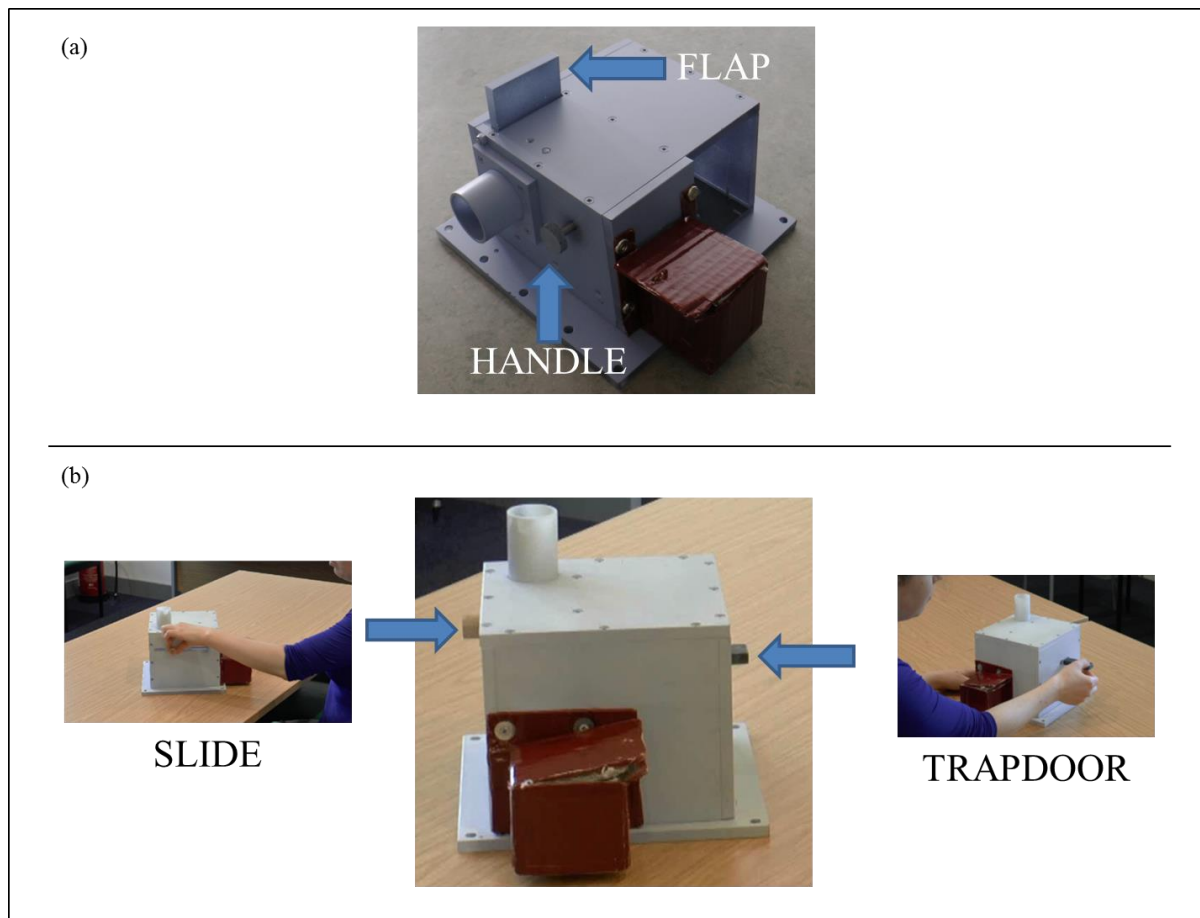
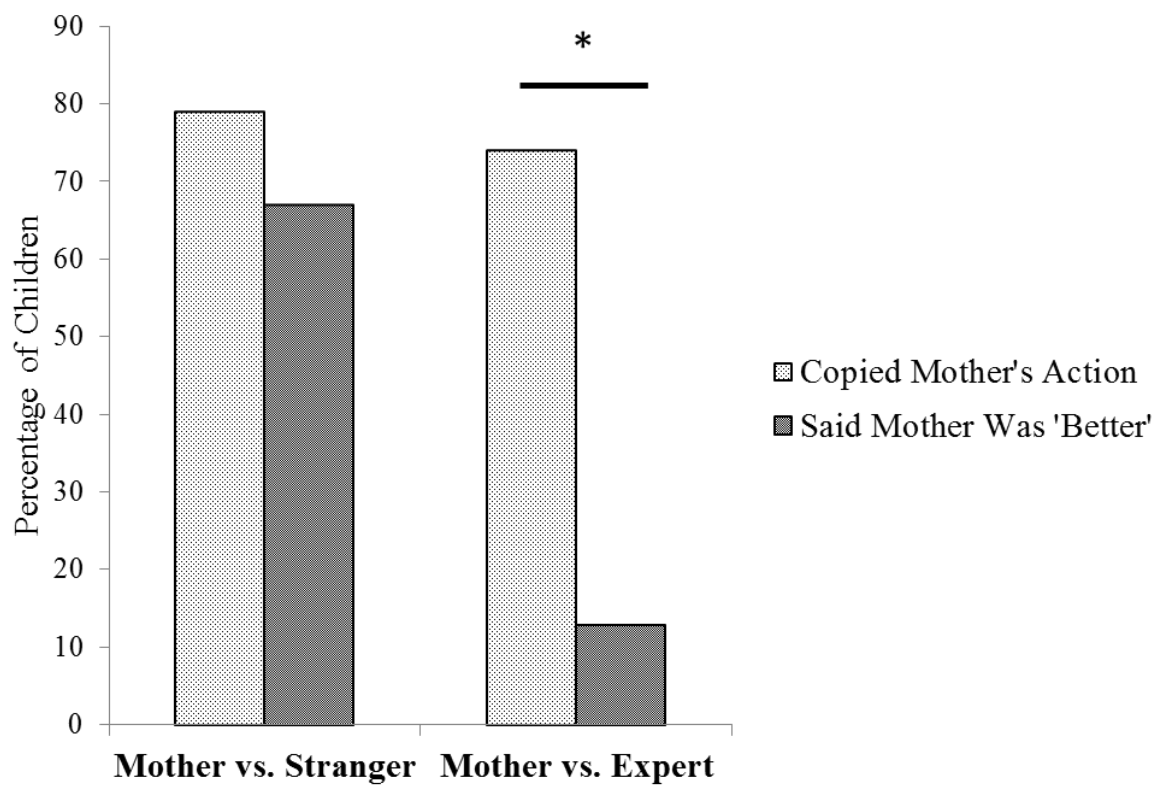


Figure 2

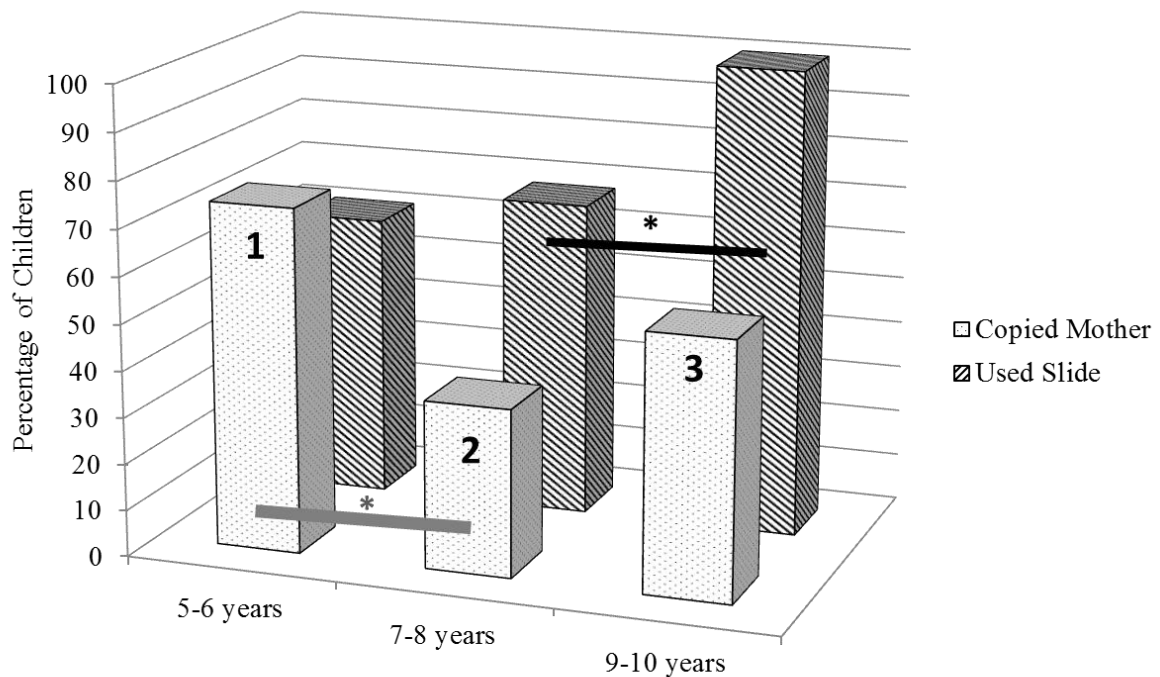
Percentage of Children Who Copied their Mother and Claimed their Mother was 'Better'



* $p < .001$; Children who attempted both demonstrated methods (N=3) are not included in the analysis.

Figure 3

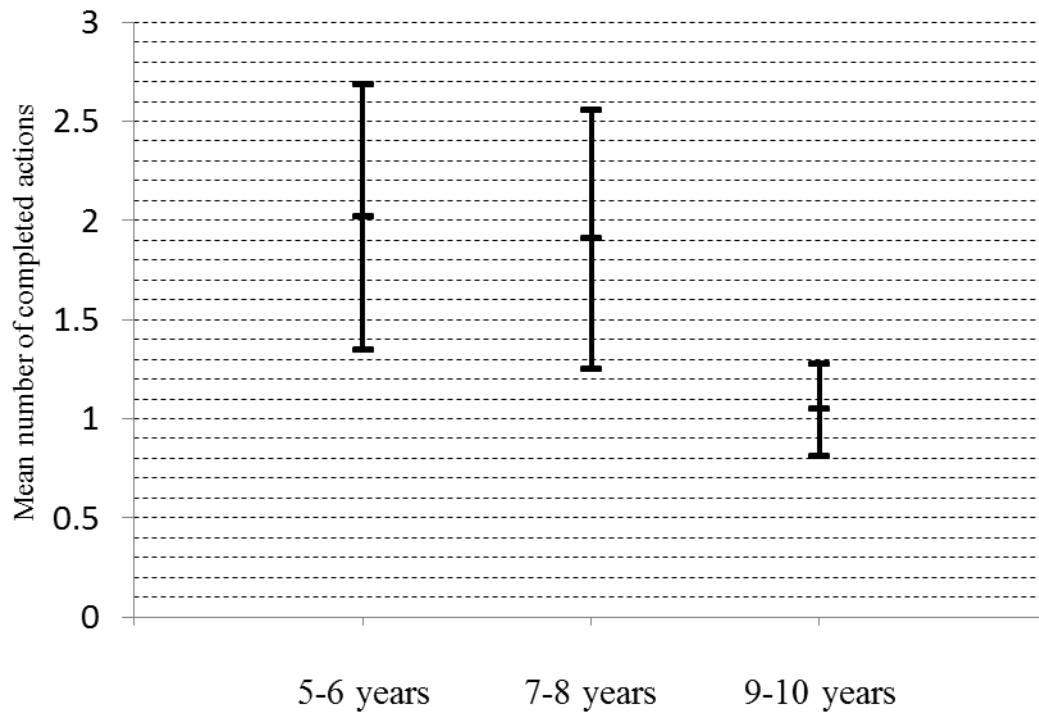
Percentage of Children Who Copied their Mother (rather than the Expert) and Used the Slide Action (rather than the Trapdoor).



*For age-categories 1 and 2 children are at chance in their use of the Slide vs. the Trapdoor. They demonstrate a model bias towards their Mother (1) and then demonstrate a significant shift towards copying the Expert (2). At age-category 3 100% of children use the Slide rather than the Trapdoor, neglecting model biases in favor of their own causal understanding or naïve physics. Children who attempted both demonstrated methods (N=8) are not included in the analysis. * $p < .05$, * $p < .001$*

Figure 4

Mean Number of Times (with 95% Confidence Intervals) that Children completed their Chosen Action



Children who attempted both demonstrated methods (N=8) are not included