

## Unselective Overimitators: The Evolutionary Implications of Children's Indiscriminate Copying of Successful and Prestigious Models

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Children are both shrewd about whom to copy—they selectively learn from certain adults—and overimitators—they copy adults' obviously superfluous actions. Is overimitation also selective? Does selectivity change with age? In two experiments, 161 two- to seven-year-old children saw videos of one adult receiving better payoffs or more bystander attention than another. Children then watched the adults perform unnecessary actions on novel transparent devices. Children preferred the adult who received greater payoffs or bystander attention when asked questions like "Who do you think is smarter?" but overimitated both adults' unnecessary actions equally. Although older children overimitated more, unselectivity was consistent across ages. This pattern hints at a plausible adaptive function of overimitation: acquiring rarely demonstrated behaviors by practising them immediately.

Young children are surprisingly discerning learners. Right from infancy they make choices about who to attend to, who to copy, and who to trust (for recent reviews, see Harris, 2012; Wood, Kendal, & Flynn, 2013). They do this across many domains, including learning object names (Brosseau-Liard & Birch, 2011; Koenig & Harris, 2005; Scofield & Behrend, 2008), artifact functions (Birch, Vauthier, & Bloom, 2008; Birch, Akmal, & Frampton, 2009), nonobvious causal properties (Sobel & Corriveau, 2010), and food preferences (Chudek, Heller, Birch, & Henrich, 2012).

Children's selective learning has been invoked to test evolutionary claims about how human cultural transmission first arose. Though our culture-pioneering ancestors' patterns of selective learning are the focus of a great deal of evolutionary theorizing (e.g., Boyd & Richerson, 1988; Cavalli-Sforza & Feldman, 1981; Chudek, Muthukrishna, & Henrich, 2015; Henrich & Henrich, 2007; Laland & Brown, 2011; Mesoudi, 2009; Richerson & Boyd, 2004), they can no longer be directly observed. However, adaptation claims can be tested by comparing the predictions of evolutionary models to the selective dispositions of contemporary children (for a review, see Chudek, Brosseau-Liard, Birch, & Henrich, 2013).

Young children are also remarkably faithful copiers. Children insist on copying superfluous steps,

even when experimenters attempt to convince them that those steps are "silly" (Lyons, Young, & Keil, 2007), remove potential social demands, add costs to performing nonessential steps (Lyons, Damrosch, Lin, Macris, & Keil, 2011), and even when the child merely "overhears" the demonstration rather than being taught directly (Nielsen, Moore, & Mohamedally, 2012). Researchers now call this persistent copying of redundant steps "overimitation." This pattern of behavior stands in sharp contrast to our primate relatives who when they see someone perform several obviously unnecessary steps to achieve an end—usually extracting some food from a puzzle box—copy the steps that are essential and ignore those that are not (Horner & Whiten, 2005).

Overimitation is remarkably widespread among humans. Western, educated, industrialized, rich, democratic (Henrich et al., 2010) adults overimitate (Flynn & Smith, 2012; McGuigan, Makinson, & Whiten, 2011), Kalahari Bushman overimitate (Nielsen & Tomaselli, 2010; Nielsen, Mushin, Tomaselli, & Whiten, 2014), Australian aboriginals overimitate (Nielsen et al., 2014), children with Down syndrome overimitate (Nielsen & Hudry, 2010), and even children with autism have been reported to overimitate (Nielsen & Hudry, 2010), except when using familiar objects (Marsh, Pearson, Ropar, & Hamilton, 2013). Some normally developing chil-

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dren even insist that puppets should overimitate (Kenward, 2012).

Especially in light of its cross-cultural ubiquity and early developmental foundation, children's proclivity to overimitate has become a hotbed of debate about the evolutionary functions of this plausible cognitive adaptation. Is it part of a "copy-all, correct-later" strategy, coevolved with our massive cultural repertoires and long extended childhoods (Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009)? Is it the tell-tale overapplication of an automatic causal encoding system (Lyons et al., 2011), adapted to navigate our species' causally opaque artifact-rich worlds? Is it a strategy for thriving in a world filled with rules, conventions, norms and rituals, where deviance might be punished (Chudek & Henrich, 2011; Herrmann, Legare, Harris, & Whitehouse, 2013; Kenward, Karlsson, & Persson, 2011; Keupp, Behne, & Rakoczy, 2013; Turner, Nielsen, & Collier-Baker, 2014)? Is it a response by children to perceived social pressures, such as a desire to affiliate with adults (Nielsen, 2006; Nielsen & Blank, 2011; Over & Carpenter, 2012)?

These ultimate-level explanations of overimitation are neither exhaustive nor mutually exclusive—diligent copying of seemingly unnecessary actions may have given our child-ancestors many different advantages over their contemporaries. However, the relative plausibility of these accounts can be empirically teased apart by the distinct predictions they make about how selectively children will imitate whom, along which dimensions.

For instance, evidence that children more faithfully overimitate highly skilled models would lend weight to theories that emphasize overimitation as an adaptation for acquiring tool-use skills. After all, skill at using tools (e.g., spear-throwing, stone-shaping, or food-processing techniques) is distributed unevenly between more competent and less competent models, and copying the better technique can have pronounced fitness consequences but copying less-skilled individuals could lead to fitness costs. If, on the other hand, children are insensitive to model skill but instead prefer to copy co-ethnics over outsiders, we would gain confidence in accounts of overimitation's role in learning rituals and conventions, which differ across group boundaries. Evidence that children are especially inclined to overimitate whomever others are attending to (*prestigious* models) would support accounts of overimitation's role in making cultural learning more efficient and adaptive.

Developmental changes in selectivity about overimitation can also tease apart ideas about its

putative adaptive function. Evidence that children are already selective from an early age and remain so would lend weight to accounts proposing that overimitation's function is one that it always pays to practice selectively with different status models, such as seeking social affiliation and alliance. On the other hand if children never become selective about overimitation, we would be more swayed by logic that ascribes to overimitation a benefit that is largely independent of model status, such as the advantages of copying all you see and correcting later. If we observed selectivity increasing with age, we would gain confidence in accounts of overimitation that emphasize a learning challenge—such as norm acquisition—that changes as you get older.

To date, little research has examined whether people selectively overimitate the actions of more competent others. What little research has been done suggests that individuals overimitate adults more than children (McGuigan et al., 2011; Wood, Kendal, & Flynn, 2012), and that adults are more likely to overimitate experimenters than fellow participants (Flynn & Smith, 2012). It remains an open question whether children's overimitation is sensitive to differences in models' credibility, skill, or status. Only one study has come close to addressing this: Wood et al. (2012) report that models' professed knowledge (specifically, "I know this game, I've played with it lots of times, I know exactly how to do this" vs. "This is a new game, I have never seen it before, I don't know how to do it") has little influence on 5-year-olds' proclivity to overimitate them.

Here we carry forward the important endeavor of examining whether overimitation is selective (and if so, under what circumstances and at what ages) by documenting children's proclivity to selectively overimitate with respect to model status cues. In two experiments, we varied the status of models along two dimensions (between subjects): *success*—the quality of outcomes a model accrues—and *prestige*—the amount of selective attention that other people (herein "bystanders") pay to a model. We examined whether these manipulations led to selective overimitation in children aged 2–7, exploring the developmental window around the 5-year-old insensitivity observed by Wood and colleagues. We examined success and prestige as status dimensions because they have been effective in previous empirical work and because formal theories of the evolutionary origins of cultural learning predict that cultural learners should be especially attentive to them (Boyd & Richerson, 1988; Henrich & Gil-White, 2001; Henrich & McElreath, 2003; Richerson & Boyd, 2004).

Our prestige cue extends empirical work (Chudek et al., 2012), which found that bystanders' preferential attention to a model increased children's likelihood of imitating that model. This has also been observed in adults (Atkisson, O'Brien, & Mesoudi, 2011). Our prestige cue builds on evolutionary theory demonstrating that others' attention is a robust indicator of model quality (Henrich & Gil-White, 2001). Our success cue builds on empirical work showing that children prefer individuals who have been the beneficiaries of good outcomes (Olson, Banaji, Dweck, & Spelke, 2006). It instantiates a simple and central evolutionary prediction about selective cultural learning: that fitness outcomes should matter.

Our search for evidence of selectivity in overimitation began with a *Parallel Actions* experiment. In this design, two differently cued (high status and low status) models each demonstrated how to use a different puzzle box. If children are selective about overimitation, we predicted they would be more likely to copy redundant steps performed by the high status model.

## Parallel Actions Experiment

### *Method*

#### *Participants*

We recruited 96 visitors (50 males) to the Science World science museum in Vancouver, Canada between January and June 2011. Their ages ranged from 2 years, 4 months to 7 years, 5 months ( $M_{\text{age}} = 5.12$  years,  $SD = 1.08$  years), detailed distributions are available in Table S1. In each experiment, sample sizes were not chosen in advance. Rather, as many participants as possible were recruited in a single semester, limited by time and research assistant availability.

#### *Materials*

*Status videos.* Participants viewed one of two prerecorded videos showing two adult female models who differed in either prestige or success (i.e., between-subjects). Both models were white, in their mid-twenties and dressed identically. One had curly light-colored hair and the other had straight dark hair. Pilot subjects seemed to have no trouble discriminating between them. All videos were viewed on a 15.4 in. computer screen.

The prestige video consisted of two 10-s clips (each child saw both), each showing our two mod-

els at either end of a table working with small tools (in one clip: both models manipulate magnetic construction toys, mostly obscured by the models' hands; in the other: small metal boxes with switches and dials on them). Both models remained entirely focused on their hands throughout. To manipulate prestige of the models, in both clips, two bystanders carefully watch what one model was doing (the high status model) and entirely ignore the other. We showed two clips to each participant, each with a different pair of bystanders, to encourage the impression that many different people in different contexts preferentially attend to the high status model.

The success video was a single 30-s video depicting the two models at either end of a table flipping switches on two metal boxes. After a few seconds, each model retrieves a sheet of paper from their respective device. The high status model says "I got five stickers," and the low status model says "I only got two." The models then switch sides and use the other device, and once again repeat the same statements in the same order. To clarify, the high status model receives five stickers (a currency children value) from each device, whereas the low status model always receives two. As with the prestige videos, children saw two demonstrations of one model's higher success. In this case, we show a single video with models switching devices to encourage the impression that some property of the model and not the devices leads to better outcomes.

*Puzzle boxes.* We constructed two distinct puzzle boxes, the Rod Box and Pull Box (see Figure 1), and carefully matched the necessary and redundant steps that models used to operate them. Children could, most simply, use their hand to open a single door (Step 8) and retrieve a target toy (Step 10) from each device. Alternatively (see Table 1), they could retrieve an entirely redundant tool (Step 1), by unnecessarily rotating it first (Step 2), removing another large superfluous piece of the device (Step 3), by hand or by using the tool (Step 4), tap the top of the device with the tool (Step 5), rotate a causally disconnected propeller or hinge (Step 6), by hand or by using the tool (Step 7), and finally they could needlessly use the tool to perform the essential steps (Steps 9 and 11). We prepared videos of each model performing all 11 steps to retrieve the toy.

#### *Procedure*

After greeting the child, the experimenter initiated a warm-up phase by explaining that "We're going to play a game. This game is about finding

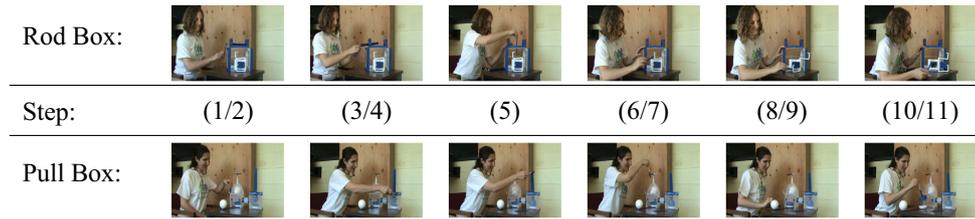


Figure 1. The steps demonstrated for each puzzle box; described in detail in Table 1.

Table 1  
The Steps Demonstrated for Each Puzzle Box

Step	Rod Box	Pull Box
1	Uses tool?	Uses tool?
2	Rotates tool?	Rotates tool?
3	Removes Rod?	Removes hinge?
4	(Using tool?)	(Using tool?)
5	Taps top?	Taps top?
6	Opens top door?	Turns propeller?
7	(Using tool?)	(Using tool?)
8	<b>Opens bottom door?</b>	<b>Pulls tray?</b>
9	(Using tool?)	(Using tool?)
10	<b>Pulls out toy?</b>	<b>Opens lid?</b>
11	(Using tool?)	(Using tool?)

Note. Essential steps are marked in bold.

the toy in the device and bringing it to me. The first device is really easy, it's just over there. Can you bring me the toy?" The experimenter held out her hand and looked away. Except for a few younger children who needed further encouragement, the experimenter did not respond until the child had placed the toy in their hand. The first device was a simple plastic ring with the toy—a small plastic bear—clearly visible inside and easily retrievable. The same procedure was then repeated for a second "device," a toy partially visible under a plastic cup. This second device required children to actually move something aside in order to access the toy. Upon receiving the toy, the researcher praised the child, saying "That was so easy. You're really good at this."

This procedure was designed to (a) familiarize children with going to find the toy while the researcher waited, (b) make them feel safe interacting with "devices" in an unfamiliar environment, (c) build their motivation to find and retrieve the toy, and (d) establish the researcher cared primarily about getting the toy and was not watching how they interacted with the "device."

The researcher then said: "The next device is harder, so let's watch some videos of how my friends do it." They then played the status videos.

Each child saw only one cue—success or prestige—according to their experimental condition. Following the cues, the researcher made the toy finding task salient again, pointing to a puzzle box located behind them and saying "The next device is over there, but it's harder. Let's see how my friend does it. This is her way. You don't have to do it her way." Children then watched a demonstration video.

Next the experimenter said "OK, that was her way. Now it's your turn, you can do it your way. Can you bring me the toy?," held out her hand and looked away from the puzzle box. The child's interactions with the puzzle box were noted by a second experimenter, who had not been introduced to the child and was not involved in administering any of the tasks.

This procedure was then repeated for a second, different puzzle box, including a video of the second, identically introduced model providing the demonstration. After completing this second task, the experiment ended.

#### Analytic Procedure

Our puzzle-box steps are not independent. For instance, if a child does not retrieve the tool (Step 1) they cannot use it in any of the other steps (Steps 2, 4, 5, 7, 9, 11); if they do not remove the large piece (Step 3), they cannot do it using the tool (Step 4), and so on. Consequently, the sum of steps each child performed will show deceptively volatile fluctuations and not conform to any simple probability distribution. In light of this, we employed two analytic procedures.

In Figures 1, S1, and S2 and in text when reporting proportions, we provide 95% binomial confidence intervals. For more precise inferences, we follow Lyons et al. (2007) in analyzing the single binary outcome: whether the child performed the most salient, most obviously causally superfluous step (Step 3)—which we call "the focal step." We use logistic regression models to investigate whether imitation of the focal step was selective,

controlling for various potential confounds and demographic factors.

We randomized and statistically modeled the following variables: whether the child saw prestige or success cues, which model had higher status, which model performed their demonstration first, which model demonstrated which puzzle box, and which puzzle box children saw first.

### Results and Discussion

#### Did Children Overimitate?

Yes: Figure 2 shows the frequency of imitation of each step, for each box. 37.5% (95% CI: 27.8, 47.9) of participants imitated the focal step of the more difficult Pull Box procedure whereas 55.2% (95% CI: 44.7, 65.3) of participants imitated the Rod Box procedure. Given this difference, we analyze the two boxes separately. Pairing of model status and puzzle box was randomized in experiments and statistically controlled in all analyses.

These overimitation rates are consistent with existing work, where children's likelihood of copying redundant steps has varied considerably between studies. When children see live demonstrations of very simple tasks, it is not uncommon to see more than 80% of children overimitate (e.g., Kenward et al., 2011; Lyons et al., 2007; Nielsen & Tomaselli, 2010). Imitation rates similar to our participants' are observed when children face more complex devices (e.g., Lyons et al., 2007, Dome & Cage devices) or relatively information-sparse video demonstrations (e.g., McGuigan, Whiten, Flynn, & Horner, 2007), even when they are imitating causally relevant actions (Flynn & Whiten, 2013). These differences are plausibly the result of variable task difficulty: how easily a child can see what the model is doing, how many steps are performed and how hard it is to remember them, how much time elapses between demonstration and testing, and so on. The phenomenon that has catalyzed evolutionary explanations is that in all cases children, including our participants, overimitate at substantially

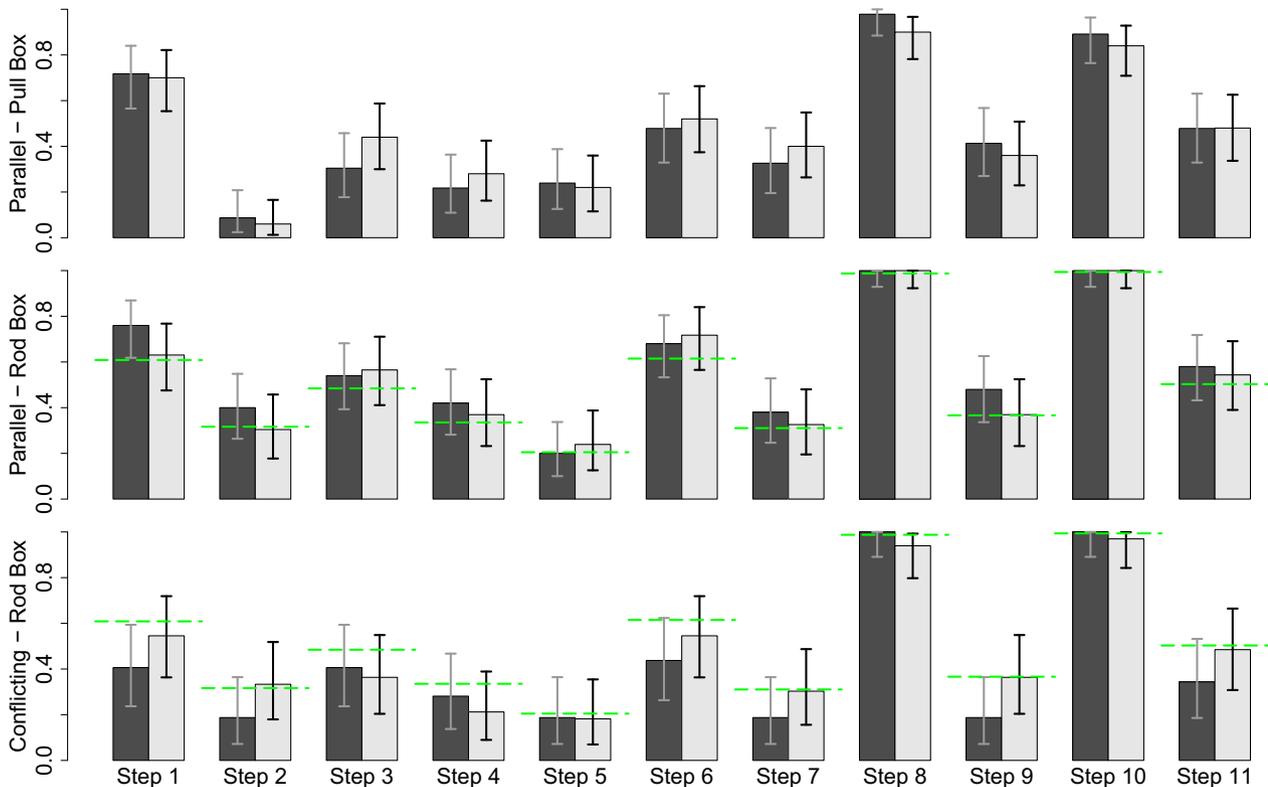


Figure 2. The rates at which children imitated each step (horizontally) in each study (vertically). Darker bars show imitation of the high status model in the Parallel Actions study or in conditions where the high status model demonstrated more steps in the Conflicting Actions study. Lighter bars show the same for the low status model. Binomial 95% confidence intervals are indicated for each bar. Dashed lines show the average rate of imitation for each step of the Rod Box, across both studies. Had children selectively overimitated the high status model, the darker bars would be taller than the lighter bars. This figure pools both prestige and success conditions; they are presented separately in Figures S1 and S2.

higher rates than nonhuman primates, who overimitate between 0% and 6% of the time (Horner & Whiten, 2005).

#### Did Children Overimitate Selectively?

*No:* The dark bars in Figure 2 show the imitation rates of children who observed high status models (i.e., more prestigious or more successful model), the lighter bars show those of children who saw low status models. If overimitation were selective—or at least sensitive to our prestige and success cues—the dark bars would be higher. However imitation rates did not differ between children imitating high and low status models any more than would be expected by sampling error alone. These patterns are independently true for children who saw prestige cues and those who saw success cues (see Figures S1 and S2).

Consider the focal step in particular. Table 2 describes logistic regression models, which control for possible extraneous influences on children's behavior that were randomly distributed among conditions: their age, sex, the device used, the identity of the model, and the order in which stimuli were presented. Children saw the high status model demonstrate one puzzle box and the low status model demonstrate another. As noted above, the Pull Box turned out to be considerably more challenging for children, so we consider each separately.

When interacting with the Rod Box in prestige conditions, 51.7% (95% CI: 32.5, 70.6) of children who saw the high status model imitated the focal step, whereas 60.9% (95% CI: 38.5, 80.3) of children who saw the low status model imitated the focal step. Controlling for extraneous influences, there was a nonsignificant trend for high status models to *decrease* the odds of imitating this step by 0.6 (95% CI: 0.17, 2.09;  $p = .42$ ). In success conditions, these rates were 57.1% (95% CI: 34, 78.1) and 52.1% (95% CI: 30.6, 73.2), respectively, and the odds ratio was 1.59 (95% CI: 0.40, 6.30;  $p = .5$ ). These apparent effects are quite plausibly the result of sampling error alone.

When interacting with the Pull Box in prestige conditions, the rates for high status conditions and low status conditions, respectively, were 34.8% (95% CI: 16.4, 57.3) and 44.8% (95% CI: 26.4, 64.3). Model status increased the odds of overimitation by 0.82 (95% CI: 0.22, 3.04;  $p = .77$ ), which is very plausibly the result of sampling error alone. In success conditions, these statistics were as follows: 26.1% (95% CI: 10.2, 48.4) for high status models, 42.9% (95% CI: 21.8, 66) for low status models, and an effect on odds of 0.17 (95% CI: 0.03, 0.99;  $p = .049$ ). This one effect does barely pass conventional significance thresholds. However, given conventional 5% thresholds, we expect one significant effect in 20 test due to sampling error alone. We caution readers against drawing strong post hoc inferences about this isolated subsample effect.

Table 2  
Parallel Actions Experiment

	Rod, intr.	Rod, pres.	Rod, succ.	Pull, intr.	Pull, pres.	Pull, succ.
(Intercept)	+0.23 (0.22)**	-0.17 (0.72)**	-0.37 (0.89)**	-0.69 (0.25)**	-0.44 (0.79)**	-2.32 (1.18)**
Selective	-0.11 (0.44)**	-0.51 (0.63)**	+0.47 (0.70)**	+0.87 (0.50)**	-0.20 (0.67)**	-1.75 (0.89)**
Prestige?	-0.03 (0.44)**			+0.21 (0.47)**		
Age	+0.50 (0.22)**	+0.42 (0.27)**	+0.47 (0.42)**	+0.73 (0.25)**	+0.78 (0.32)**	+1.09 (0.53)**
Male?	+0.69 (0.44)**	-0.03 (0.64)**	+1.22(0.68)**	+0.34 (0.47)**	+0.79 (0.68)**	+0.19 (0.74)**
High first?	+0.27 (0.44)**	+0.32 (0.62)**	+0.37 (0.67)**	-0.74 (0.50)**	-0.75 (0.67)**	-0.95 (0.80)**
High model?	+0.00 (0.44)**	+0.86 (0.63)**	-0.79 (0.66)**	-0.07 (0.47)**	-0.82 (0.68)**	+0.88 (0.77)**
Rod first?	+0.07 (0.44)**	+0.22 (0.63)**	-0.05 (0.68)**	+0.55 (0.50)**	+0.43 (0.67)**	+0.87 (0.82)**
Selective × Pres.	-1.15 (0.90)**			-1.09 (0.98)**		
N	96	52	44	96	52	44

*Note.* Logistic regression models of whether children imitated the focal step in the Parallel Actions experiment, when using the *Rod* or *Pull* box, having seen success (*succ.*) or prestige (*pres.*) cues, and the interaction (*intr.*) between these and status cues. The *Selective* predictor encodes whether the high status model demonstrated the corresponding box (i.e., the Rod Box in *Rod* models). To evidence selective overimitation, the coefficient for this predictor should be positive and significant. *Age* is the child's age in years, centered within each model. The other predictors encode: *Male?*: whether the participant was male; *High first?*: whether they saw the high status model first; *High model?*: which of the two actors played the high status model, *Rod first?*: whether the Rod Box was demonstrated first or second. To make both intercepts and coefficients meaningful, all dichotomous predictors are coded: (-0.5, 0.5). Coefficient standard errors are in parentheses. \* $p < .05$ . \*\* $p < .01$ .

We saw no clear evidence that children consistently preferred overimitating high status models. Children often tended to imitate *fewer* of the high status model's redundant steps, though this was statistically indistinguishable from their being unselective.

#### *How Did Overimitation or Selectivity Change With Age?*

Children's age was recorded in days and modeled as a continuous predictor in logistic regression models of children's proclivity to overimitate and be selective. Older children were more likely to overimitate the focal step of both the Rod and Pull Box procedures. For every year of age, the odds of children imitating the Rod Box focal step increased by 1.55 (95% CI: 1.02, 2.37), and the odds of imitating the Pull Box focal step increased by 1.95 (95% CI: 1.24, 3.08).

We saw no clear evidence of older children having a different likelihood of being selective about imitating either the Rod Box procedure (OR = 1.19; 95% CI: 0.79, 1.76;  $p = .40$ ) or the Pull Box procedure (OR = 1.0; 95% CI: 0.68, 1.48;  $p = .98$ ). The fact that this age effect was larger for the Pull Box is consistent with the lower absolute rates of overimitation for this device being a consequence of task difficulty.

### **Conflicting Actions Experiment**

When children's overimitation proved unselective in our Parallel Actions experiment, we suspected that children may require some conflict between the information provided by two models before they discriminate between them. That is, if a child has information about a novel device from only one source, many evolutionary accounts of the function of overimitation could plausibly claim that the child should always use that information. However, when two sources provide conflicting information, whether and how one would expect a child to navigate that conflict will depend on the assumed adaptive function of overimitation. Specifically, when the dimension on which the models vary aligns with overimitation's purported adaptive function (e.g., a history of tool-use success if overimitation is for acquiring tool-use skills, higher prestige if overimitation is for coalitional affiliation), we would expect a well-adapted psychology to favor high status models when conflicts arise.

In a second *Conflicting Actions* experiment we presented children with two differently cued models (i.e., high and low success and prestige) who

demonstrated how to use the same puzzle box, but one demonstrated fewer steps. We expected that selective overimitators would imitate fewer steps when the high status model demonstrated fewer and imitate more when the high status model demonstrated more.

The Parallel Actions experiment focused on the tension between a participant's intuition that an action is redundant and the social information conveyed by an adult model performing the action. Although status cues may have changed the value of that social information, if children place a very low weight on their own intuitions relative to social information this change would have no impact on their behavior. By putting the implicit testimony of the models themselves into conflict, the Conflicting Actions experiment sought to reduce the behavioral influence of participants' weighting of their own intuitions.

#### *Method*

##### *Participants*

A total of 65 children (32 males) participated in the Conflicting Actions experiment. Their ages ranged from 2 years, 7 months, to 7 years, 6 months ( $M_{\text{age}} = 4.42$  years,  $SD = 1.06$  years), detailed distributions are available in Table S1. In contrast to the Parallel Actions experiment, these participants were recruited from a subject database and were tested on campus between the months of March and June 2013. This change in testing venue was due to a change in access to the museum sample. The demographics of both locations are quite similar as was the testing environment (roughly  $8 \times 10$  child-friendly laboratory rooms).

##### *Apparatus*

Participants saw the status cues used in the Parallel Actions experiment and the same video demonstration of models interacting with one of the puzzle boxes—the Rod Box. We prepared videos of each model performing just the essential steps (Steps 8 and 10) to retrieve the toy.

##### *Procedure*

The procedure was identical to the Parallel actions experiment, except for the following changes and additions.

To ensure that children had understood the cuing videos, children were asked: "which is more, two or five?" in success conditions and "which girl

were the people watching?" and asked to point to photos of the two girls in prestige conditions. Children who failed these questions watched the cues a second time. No children failed these control questions a second time.

After the first model had demonstrated their technique for operating the puzzle box, the researcher next said "That's her way. Let's see how my other friend does it" and played a second demonstration video for the same device. This time the other model accessed the toy by performing only the essential steps.

Children's interactions with the puzzle boxes were recorded on video and coded later by the experimenter. A subset (22%) were independently recoded by a second coder who was not present during the experiments. Agreement between the two coders was reached on 97% of actions, yielding a Cohen's kappa of .96. Coders had no disagreements about the focal step.

As it became apparent that children were not overimitating selectively even in the context of conflicting information, we added a manipulation check to ensure that our status cues were influencing children's cognitive representations of the models. When the final 25 participants had completed all the other procedures, the experimenter presented them with photos of the two models and asked each of the following questions in turn (each question is followed by the variable name used in Figure 3): "Who is the smartest?" (Smartest), "Who has the most friends?" (Most Friends), "Who would you rather be friends with?" (Friends With), "Who do you think is better?" (Better), "If you didn't know what an animal was called, who would you ask?" (Ambiguous Animal),

and "Which girl's picture would you like to take home?" (Picture). Children responded by pointing to one of the two photos. In this experiment, we randomized and statistically modeled the following variables: whether the child saw prestige or success cues, which model had higher status, and whether the high or low status model performed their demonstration first (and thus performed more steps).

## Results

### Did Children Overimitate?

*Yes:* Not only did children in the Conflicting Actions experiment overimitate, they did so at almost the same rate for each step as participants in the Parallel Actions experiment. Even though children saw a second model skip the Rod Box's redundant steps, 38.5% (95% CI: 26.7, 51.4) still persisted in overimitating the superfluous focal step performed by the first model. In Figure 2, we have indicated the average rate at which each step was imitated across all experiments using a green dotted line. The rate at which children performed each step almost never significantly differed between the experiments, despite the children having seen a model retrieve the toy using fewer steps.

### Did Children Overimitate Selectively?

*No:* Detailed regression models of the probability that children imitated the focal step are presented in Table 2. Children's lack of selectivity is visually apparent in the the lack of difference between light and dark bar heights in Figure 2.

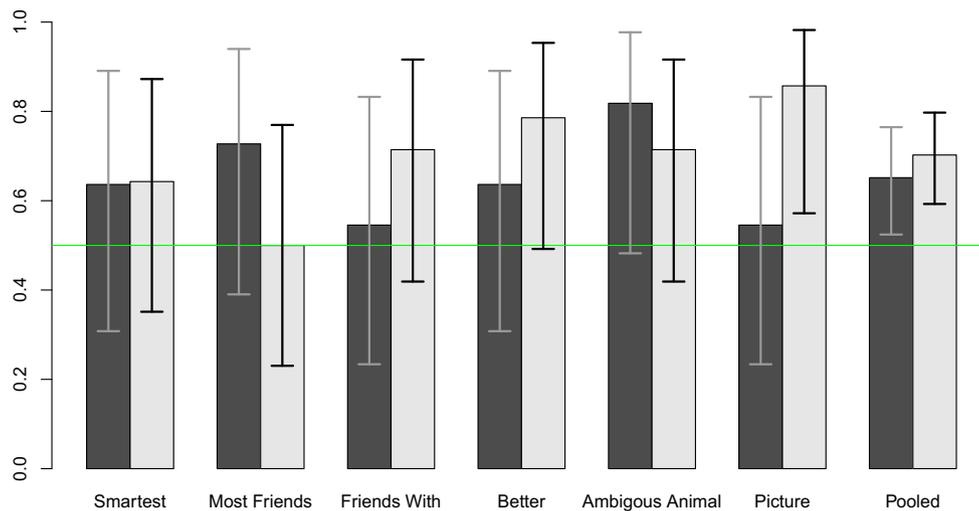


Figure 3. The frequency with which children answered explicit verbal questions in favour of the high status model, with binomial confidence intervals. Darker bars show prestige conditions, lighter bars show success conditions. The horizontal line indicates performance at chance.

Table 3  
Rod Box, Both Experiments

	Both exp.	Conflict, intr.	Conflict, pres.	Conflict, succ.
(Intercept)	−0.06 (0.16)**	−0.48 (0.26)**	−1.79 (0.94)**	−1.03 (0.80)**
Selective	+0.00 (0.32)**	+0.22 (0.53)**	+1.50 (0.96)**	−0.32 (0.76)**
Prestige?	−0.13 (0.33)**	−0.11 (0.54)**		
Age	+0.33 (0.16)**	−0.09 (0.27)**	−0.32 (0.36)**	−0.05 (0.44)**
Male?	+0.47 (0.33)**	+0.29 (0.54)**	−1.10 (0.88)**	+1.33 (0.79)**
High model?	+0.27 (0.33)**	+0.89 (0.57)**	+2.01 (0.98)**	+0.36 (0.80)**
Selective × Pres.	−0.20 (0.66)**	+1.10 (1.07)**		
N	161	65	33	32

Note. Logistic regression models of whether children imitated the focal step of the Rod Box across both experiments, and in the Conflicting Actions experiment alone, having seen success (*succ.*) or prestige (*pres.*) cues, and the interaction (*intr.*) between these and status cues. The *Selective* predictor encodes whether the high status model demonstrated the corresponding box in the Parallel Actions experiment, or appeared first and so demonstrated more steps in the Conflicting Actions experiment. To evidence selective overimitation the coefficient for this predictor should be positive and significant. *Age* is the child's age in years, centered within each model. The other predictors encode: *Male?*: whether the participant was male; *High model?*: which of the two actors played the high status model. To make both intercepts and coefficients meaningful, all dichotomous predictors are coded: (−0.5, 0.5). Coefficient standard errors are in parentheses. \* $p < .05$ .

In the Conflicting Actions experiment, children always saw one model demonstrate all 11 steps, followed by a second model who demonstrated just the essential steps. In prestige conditions when the model who demonstrated more steps was high status, 43.8% (95% CI: 19.8, 70.1) of children imitated the focal step, when they were low status 29.4% (95% CI: 10.3, 60) of children did; high status increased the odds of imitating by 4.5 (95% CI: 0.68, 29.76;  $p = .12$ ). In success conditions, the rates were 37.5% (95% CI: 15.2, 64.6) and 43.8% (95% CI: 19.8, 70.1) respectively, and the odds ratio was 0.73 (95% CI: 0.16, 3.25;  $p = .67$ ).

Considered in the context of our multiple statistical comparisons, the lack of significant interaction effects between selectivity and cue type (see Tables 2 and 3) even at conventional  $\alpha = .05$  levels, the fact that effect magnitudes and directions fluctuate dramatically across the conditions and experiments and cancel out when pooled (see the "Both Exp." model in Table 3), our data show no evidence of selectivity. They appear to be sampled from a population where model status has no effect on overimitation.

#### How Did Overimitation or Selectivity Change With Age?

In the Conflicting Actions experiment alone, we did not see clear evidence that overimitation increased with age (OR = 0.93; 95% CI: 0.56, 1.14;  $p = .78$ ). However, because the same Rod Box was used in both experiments, our most statistically powerful inference about how overimitation changes with age can be obtained by pooling data from both experiments. Overall the odds of older

children overimitating the Rod Box focal step were 1.39 (95% CI: 1.03, 1.89) times greater for every year they were older than their peers.

We saw no evidence of age differences in selectivity in the Conflicting Actions experiment (OR = 0.64; 95% CI: 0.38, 1.10;  $p = .11$ ) nor in our more statistically powerful pooled sample of all children's interactions with the Rod Box (OR = 0.94; 95% CI: 0.71, 1.25;  $p = .67$ ). Across both our experiments, older children overimitated more—perhaps because they were better at observing and recalling the video-based demonstrations—but were no more or less likely to be selective about who they overimitated.

#### Did We Effectively Cue a Difference in Models' Success and Prestige?

One potential explanation of children's lack of selective overimitation is that the participants were not sensitive to our model status manipulations. We believe this explanation is unlikely given children's responses to the manipulation checks. In the Conflicting Actions experiment, we tested whether children understood whether 2 or 5 was greater (in success conditions) and whether they could recall which model had received bystander attention (in prestige conditions). Children answered these questions correctly 87% (95% CI: 77.2, 94.5) of the time.

We also asked a subset of 25 children explicit questions to establish that our cues had produced a measurable difference in how they represented the two models. The frequency with which children's explicit answers favored high status models is

shown in Figure 3. Though we have relatively little statistical power to make inferences about each question independently, the trend for every question favors the high status model. Pooling these data across questions—assuming that they all index the same disposition to favor the high status model—gives greater statistical certainty: children who saw prestige cues answered 65.2% (95% CI: 52.4, 76.5;  $p = .02$ ) of explicit questions in favor of the high status model, whereas the rate of favoring the high status model among children who saw success cues was 70.2% (95% CI: 59.3, 79.7;  $p < .01$ ).

In sum, our status cues biased children's explicit answers in consistent, statistically significant ways, detectable even with a small sample ( $n = 25$ ). In contrast, selectivity about overimitation showed inconsistent trends and was nonsignificant overall despite a considerably more powerful sample ( $n = 161$ ).

#### *Were Children's Explicit Judgements Related to Their Overimitation?*

We tested the correlation ( $\phi$ ) between whether children's performance of the focal step matched the high status model's and whether they preferred the high status model on each explicit question. We found no consistent pattern, besides what we would expect by sampling error alone. This was true of the pooled measure ( $\phi = .24$ ,  $p = .24$ ), the judgements of who was the smartest ( $\phi = -.13$ ,  $p = .53$ ), who has the most friends ( $\phi = .27$ ,  $p = .19$ ), who children wanted to be friends with ( $\phi = .22$ ,  $p = .30$ ), who was "better" ( $\phi = -.09$ ,  $p = .67$ ), who they would ask for advice ( $\phi = .23$ ,  $p = .28$ ), and whose picture they wanted to take home ( $\phi = .09$ ,  $p = .65$ ). For instance, children who said that the high status model was smarter were slightly, though not significantly, less likely to imitate the focal step when only she performed it than children who said the low status model was smarter.

### General Discussion

Across two experiments designed to examine whether children's overimitation was selective based on model status, we observed very consistent rates of overimitation. Children's proclivity to overimitate was insensitive to whether redundant steps were demonstrated by a model cued as high or low success or prestige, and only slightly reduced when a second model skipped redundant steps.

Success (a difference between models in outcomes or payoffs) and prestige (a bias to attend to

and imitate models who have received preferential attention from others) have been theoretically predicted to be especially information-rich cues for young culture learners (Boyd & Richerson, 1988; Henrich & Gil-White, 2001; Henrich & McElreath, 2003; Richerson & Boyd, 2004), and these predictions have born out in other domains (e.g., Chudek et al., 2012, 2013; Olson et al., 2006; Wood et al., 2013). In contrast, our results here suggest that overimitation is insensitive to success and prestige differences, despite children discriminating between successful and prestigious models when answering explicit questions. What implications does this have for understanding why children overimitate and its potential adaptive functions?

Here we consider four accounts of the adaptive function of overimitation: that it (a) helps children navigate others' social expectations, (b) helps them encode techniques for using causally opaque tools, (c) helps them acquire and conform to norms and conventions, and (d) is the result of a general "copy-all, correct-later" strategy adaptive in extended juvenile periods. These four accounts are not mutually exclusive. Children may overimitate for several reasons at once, the logic of "copy-all, correct-later" applies to rituals and conventions as much as tool-use skills, the same cognitive adaptations could facilitate the acquisition of tool-use skills and social norms, social norms could include copying others to satisfy their social expectations, and so on. Despite these potential theoretical interconnections, here we strive for simplicity by considering the fit of each prediction to our data in turn.

Social accounts of overimitation (e.g., Nielsen & Blank, 2011)—that children overimitate to better navigate others' social expectations—fit least well with our results. Children persisted in overimitating despite our insistence that they do it "their way" and persisted in overimitating at similar rates when one model's behavior—skipping the redundant steps—implicitly suggested that they need not do it. Children were not substantially more likely to overimitate someone who they claimed they would prefer to be friends with, or who they claimed was "better." More importantly, if one's goal is navigating the social world, prestige and success cues ought to matter. When you are considering violating an implicit social demand, it makes a big difference whether the implication came from a prestigious person to whom everyone else attends or someone whom everyone ignores.

Tool-use accounts (e.g., Lyons et al., 2011)—that children automatically encode all deliberate actions, to better master complex skills in a world filled

with causally opaque artefacts—are also hard pressed to explain this nonselectivity. After all, the uneven distribution of skills across models and the potent fitness consequences of learning a better causally opaque procedure are precisely why children are thought to be so selective in other domains. If overimitation is for learning tool-use skills, why would children not be selective about who they overimitate?

Conventional accounts (e.g., Kenward, 2012; Kenward et al., 2011; Keupp et al., 2013)—that children overimitate to better navigate a world filled with norms, rules, conventions, and causally opaque social rituals—have a more ambiguous fit to our data. One could argue that in a world where conventions can vary, can be in conflict opposition, and can be renegotiated, it makes sense to learn them from the most prestigious individual. If conventions are causally opaque but carry fitness consequences, it might make sense to learn them from the most successful. On the other hand, a “copy-all, correct-later” strategy might also make sense for norms: it may be worth imitating and mastering them immediately regardless their source and experimenting with violating them later.

One could also argue that these are not the correct dimensions of selectivity with which to test conventional accounts. Children may ignore prestige and success because they are focusing on a more convention-relevant difference: which model is from their own ethnic group. Children are certainly selective about ethnicity in other learning domains (e.g., Corriveau, Kinzler, & Harris, 2013; Howard, Henderson, Carrazza, & Woodward, 2014). Because our models bore no obvious ethnic or other intergroup markings (i.e., accent differences, apparel, etc., which children of these ages are clearly sensitive to from a young age, Baron, 2013; Baron & Dunham, 2015), our findings about success and prestige cannot speak to this question directly. Further research on overimitation’s sensitivity to ethnicity would be informative.

The account we believe fits best with our findings is “copy-all, correct-later” (Whiten et al., 2009). This perspective emphasizes a strategic dilemma faced by young learners in a cultural species. Children grow up in a complex cultural world where there is a tremendous amount of cultural information to master and valuable skills may only be demonstrated rarely. Even before the advent of cities and agriculture, foragers possessed complex tool making methods, food processing techniques, ecological knowledge and many seasonal or even once-per-lifetime rituals, all of which might only be

demonstrated to learners when unlikely circumstances aligned (e.g., resource availability, major life events, etc). To thrive in a culture-rich world, human children have very long juvenile periods compared to all our primate relatives, giving them a far longer window to acquire the complex and diverse skills needed to be productive adults (Bjorklund & Ellis, 2014; Bogin, 1990; Kaplan, Hill, Lancaster, & Hurtado, 2000; Nielsen, 2012).

A cognitive-behavioral strategy complements this life-history strategy: novel skills—or even novel social norms—should be imitated as carefully as possible whenever they are witnessed, whatever their source. There will be plenty of time to refine, cull, or even forget them later, but there may never be another opportunity to learn them. From this perspective, it makes sense that when an adult deliberately performs a novel, mysterious procedure, children would be intrinsically motivated to immediately try it themselves, however successful or prestigious the adult was. This remains true even if another adult later skips the unnecessary steps. Because the child does not know why the actions were performed, they cannot know when and why they can be omitted. In the context of a long childhood, it makes sense to copy all the novel, seemingly purposeful behaviors immediately and experiment with omitting them later.

Our goal here has been to examine the fit of children’s insensitivity to success and prestige cues to ultimate level explanations of the evolved function of overimitation. We believe our findings fit best with the ultimate evolutionary logic of “copy-all, correct-later” but are not inconsistent with conventional accounts. Further studies of selectivity along other status dimensions, such as ethnicity, prior accuracy, or emotional state, could yield valuable insights into both the potentially evolved function of overimitation and the proximate cognitive states that motivate children to overimitate today.

We hope that future studies extend our findings by tapping a broader sample and set of methods. For instance, in previous research, children have overimitated less when watching video presentations like ours (e.g., Flynn & Whiten, 2013; McGuigan et al., 2007) than when confronted with live actors (e.g., Kenward et al., 2011; Lyons et al., 2007; Nielsen & Tomaselli, 2010), and selectivity may also be sensitive to this difference. Here we witnessed overimitation increasing with age, but saw no corresponding change in selectivity, which tentatively favors accounts that suggest it does not pay to be selective about overimitation at any age. We look forward to studies that investigate other dimensions

on which children vary—for instance, cultural differences—to document more subtle patterns in children’s selective overimitation.

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### Supporting Information

Additional supporting information may be found in the online version of this article at the publisher’s website:

**Figure S1.** Imitation Rates for Success Conditions Only (see Figure 2 for Interpretation Details)

**Figure S2.** Imitation Rates for Prestige Conditions Only (see Figure 2 for Interpretation Details)

**Table S1.** The Number of Children of Each Ages in Our Two Experiments