Abstract

Many animals, including humans, acquire information through social learning. Although such information can be acquired easily, its potential unreliability means it should not be used indiscriminately. Cultural ‘transmission biases’ may allow individuals to weigh their reliance on social information according to a model’s characteristics. In one of the first studies to juxtapose two of these context dependent model-based biases, we investigated whether the age and knowledge state of a model affected the fidelity of children’s copying. Eighty-five 5-year-old children watched a video demonstration of either an adult or child, who had professed either knowledge or ignorance regarding a tool-use task, extract a reward from that task using both causally relevant and irrelevant actions. Relevant actions were imitated faithfully by children regardless of the model’s characteristics, but those who observed an adult reproduced more irrelevant actions than those who observed a child, while the professed knowledge state of the model showed a weaker effect on imitation of irrelevant actions. Overall, children favoured the use of a ‘copy adults’ bias over a ‘copy task-knowledgeable individual’ bias, even though the latter could potentially have provided more reliable information. The use of such social learning strategies has significant implications for understanding the phenomenon of imitation of irrelevant actions (or overimitation), instances of maladaptive information cascades and for understanding cumulative culture.

Keywords: imitation, transmission biases, social learning strategies, model characteristics, knowledge state.

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1. Introduction

The adaptive value of social learning is now evident in a vast range of animals, from humans to insects, resulting in implications for our understanding of cultural evolution and social intelligence (Boyd & Richerson 1985; Tennie et al., 2009; Whiten & van Schaik 2007). When acquiring information individuals face evolutionary trade-offs between the acquisition of costly but accurate personal information and the use of cheap but potentially less reliable social information (Boyd & Richerson 1985; Kendal et al., 2005). Accordingly, the implementation of social information should be determined by an evaluation of the content of the information presented and the characteristics of the information provider, the model (e.g. van Bergen et al., 2004; Rendell et al., 2010). Nevertheless, the transmission of information from one individual to another has resulted in the accumulation of errors or cascades of misinformation (Rieucau & Giraldeau 2009; Tanaka et al. 2009). For example, humans copy non-functional attributes (Mesoudi & O'Brien, 2008), with maladaptive behaviors passing between individuals within groups (McGuigan & Graham, 2009; Whiten & Flynn, 2010).

Furthermore humans copy actions that, at face value, appear to be causally irrelevant (Horner & Whiten, 2005; Lyons et al., 2007; McGuigan et al., 2007). The propensity to copy these irrelevant actions appears in different cultures (e.g. Kalahari Bushmen; Nielsen & Tomaselli, 2010), increases with age (McGuigan et al., 2007; Neilsen, 2006) into adulthood(McGuigan, Makinson & Whiten, 2010), and persists despite interventions such as reinforcement for the identification of irrelevant actions and direct instructions to only copy relevant actions (Lyons et al., 2007, 2011). Such pervasiveness has led some to view copying irrelevant actions as, 'an evolutionary

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adaption that is fundamental to the development and transmission of human culture' (Nielsen & Tomaselli, 2010, p.729). For example, Henrik and Csibra (2009) argue that imitating causally irrelevant elements of tool use demonstrations helps children acquire means actions even before they fully understand their causal role in bringing about the desired goal. If one does not know the whether an action is causally necessary it may be adaptive to copy this action.

Copying seemingly causally irrelevant actions could only be adaptive if individuals develop flexible strategies that dictate the circumstances under which they copy others. Theoretical models have explicitly considered a demonstrator's characteristics, which have been termed 'who strategies' (Laland, 2004) and 'cultural transmission biases' (Boyd & Richerson 1985; Rendell et al. 2011). According to Boyd and Richerson (1985) individuals may employ an *indirect* bias towards learning from a model with specific preferential characteristics. These indirect biases or *context-dependent* (Henrich & McElreath, 2003) model-based biases, may involve, for example, an individual's age. Using such model-based biases allows populations to approach adaptive optima much faster than they otherwise would under individual learning or 'guided variation' (Boyd & Richerson, 1985). For example, Mesoudi and O'Brien (2008) found, by simulating the cultural transmission of prehistoric projectile-points, that the population-level pattern observed in Nevada's archaeological record was consistent with a bias of *wholesale* copying of a successful hunter's projectile-point design, including non-functional but selectively neutral aspects (such as color), rather than copying particular projectile-point attributes.

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In an argument analogous to that of Laland (2004) regarding the relative abundance of cognitively challenging versus simpler social learning strategies in the animal kingdom, we argue that within a species there may be differences in the propensity to use certain model-based biases. Specifically, children may find a ‘copy adult over child’ strategy (Dugatkin & Godin, 1993) relatively easy to implement compared to a ‘copy task-knowledgeable individual’ strategy (Henrich & Broesch, 2011) for a number of reasons. Firstly, understanding of age develops earlier than an understanding of knowledge (Edwards, 1984; Wellman et al., 2001) and thus related biases may also develop earlier. Secondly, age may be a more salient characteristic and thus involve less cognitive processing and, thirdly, children may understand that self-declared knowledge states may be less reliable than age. In the current study five-year-old children received demonstrations of observably relevant and irrelevant actions in relation to the goal of extracting a reward from an artificial fruit and we investigated whether the observing child’s subsequent behavior was influenced by the model’s age and/or knowledge state.

The model-based bias of age, and the strategy of ‘copy older individuals’ is a prominent heuristic (Henrich & Gil-White, 2000; Kirkpatrick & Dugatkin, 1994). There is evidence that older models elicit more social learning in many species (e.g. seals; Sanvito et al., 2007, mice; Choleris et al., 1997, guppies; Amalacher & Dugatkin 2005, chimpanzees; Biro et al., 2003; Horner et al., 2010). Likewise, human developmental research has considered model age as a determining factor in social learning for some time. Vygotsky (1981) suggested that children learn more from older individuals as they scaffold learning, with an active intention of sharing their knowledge. Observational studies have shown that younger (1- to 2-year-olds) siblings imitated their older (3- to 5-

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year-old) siblings far more than the other way around regardless of age gap or sex differences (Abramovitch et al., 1980; Pepler et al., 1981). When presented with two models of differing ages (two years younger, same age, or two years older) simultaneously, eight year olds imitate the food preference choice of older and same age peers over younger peers (Brody & Stoneham, 1981). Similarly, when the two models presented were a child and an adult, three- and four-year-olds preferentially used information provided by an adult over a child, for word learning (Jaswal & Neely, 2006) and simple rule games, interpreting the adult's behavior as normative (Rakoczy et al., 2010)

The effect of a model's age on children's social learning is modulated by the content of the to-be-copied behavior; two-action, artificial fruits tasks have shown that 14-month-old infants (Hanna & Meltzoff, 1993) and 3-, 4- and 5-year-old children, (Flynn & Whiten, 2008; Hopper et al., 2008, 2010) demonstrate a similar level of fidelity in the imitation of relevant actions performed by a peer to that of studies with adult models (McGuigan et al., 2007). However, studies looking at the imitation of *irrelevant actions* (actions that are not causally necessary for the completion of the task) show that 2- and 3-year old children did not copy the irrelevant actions demonstrated by a peer to the same extent as irrelevant actions presented by an adult model (Horner & Whiten, 2005; McGuigan et al., 2007). Subsequently, McGuigan et al. (2010) explicitly investigated the effect of a model's age on the copying of irrelevant actions. Observers of various ages (3-year-olds, 5-year-olds and adults) copied significantly more irrelevant actions when they were modelled by an adult as opposed to a 5-year-old child. It remains unclear whether this disposition indicates a bias of 'copy adults' or the more cognitively

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complex bias of viewing a child model as 'less rational and knowledgeable' than an adult model (Flynn 2008, p. 3549).

The effect of a model's knowledge state on children's social learning strategies is less clear. By five years of age children have a concept of a model's expertise (Azmitia 1988; Birch et al., 2008, 2010; Moore et al., 1989), knowledge (Koenig & Harris 2005; Sabbagh & Baldwin 2001;Wellman et al., 2001), intention to teach (Ziv et al., 2008) and infer a model's knowledge state based on his/her age (Taylor et al.,1991). One might expect observers to rely more heavily on an individual's demonstration when that individual has professed knowledge in the specific task domain. To test a task-directed context bias one must manipulate the model's professed knowledge state of the specific 'test' task. Furthermore, although there has been theoretical speculation of the existence of a hierarchy of transmission biases (McElreath et al., 2008) the interaction between biases remains unclear. We are only aware of one study investigating the interaction of copying biases of children of a model's age and competence. In this study the competence information, exhibited in an *unrelated* task, outweighed age information such that children (aged 7- to 8-years-old), in order of preference, copied models of: high-competence peers, high-competence younger, low-competence peers and low-competence younger (Brody & Stoneman, 1985).

The current study explicitly investigated the roles of two model-based biases. In the copying fidelity of children, we contrast the model age (adult versus peer model) with one that might require greater assessment, the task-directed knowledge state (task-knowledgeable versus task-ignorant model). The completion of a two-action tool-use task (Dawson & Foss, 1965), which included causally relevant and irrelevant components, was demonstrated by one of four models differing with respect to these biases. We predicted that: (1) an observer who witnessed a model successfully extract a reward from a task would imitate the relevant actions demonstrated using the same means to extract the reward regardless of that model's characteristics. (2) In line with McGuigan et al. (2010), children who witness an adult model would exhibit higher levels of imitation of causally irrelevant actions than those who witness a child model. (3) Children faced with a task-knowledgeable model would show higher levels of imitation of causally irrelevant actions than those presented with a task-ignorant model. Finally, (4) in line with Brody & Stoneman (1985), there would be a hierarchy of transmission with a task-knowledgeable adult prompting the highest, and a task-ignorant child prompting the lowest, levels of imitation of irrelevant actions, with potential differences between the two other models allowing the hierarchy of biases to be examined further.

2. Method

2.1 Participants

Ninety-six 5-year-old children (45 males, M = 65 months, standard deviation, SD = 3.5 months) from schools in County Durham participated. There were no significant differences for sex ($\chi^2_{1, 96}$= 2.29, p = .97) or age ($F_{8,87}$= 80.1, p = .60) across the experimental conditions and the no model control.

2.2 Materials

A two-action task, the transparent version of the 'Glass Ceiling Box' (GCB; see Figure 1, Flynn, 2008; McGuigan &Graham 2009; Horner & Whiten, 2005; McGuigan et al., 2007; McGuigan et al., 2010) was used. The GCB is a transparent box with an opening at the front that can be revealed by sliding or lifting a door. The goal is to retrieve a Velcro-backed sticker reward from a tube located behind the door, by inserting a stick tool (a 22 cm rod with Velcro on the end) into the tube. The demonstrated actions directed to the door at the front of the GCB are causally necessary to retrieve the reward. The GCB has a further opening in the roof, covered by a two-bolt defence that can be removed by poking or dragging them from the opening with the stick tool. This hole leads to an empty compartment with a ‘glass ceiling’ preventing physical access to the reward, so actions directed to the bolts or the upper compartment are observably causally irrelevant to retrieving the reward.

Insert Figure 1 here

2.3 Design

A between-groups design was used, with children (N = 85) randomly allocated to one of four conditions pertaining to model characteristics (adult professing knowledge, adult professing ignorance, 5-year-old child professing knowledge and 5-year-old child professing ignorance) or a no model control (N = 11). The control group was relatively small as the GCB has been administered in several experiments (Flynn, 2008; McGuigan & Graham, 2009; Horner & Whiten, 2005; McGuigan et al., 2007; McGuigan et al., 2010) with controls showing similar levels of interaction and success as shown in the current experiment. Both models were female and unknown to the participants. After observing a video of the model’s initial entrance and profession of knowledge or ignorance about task completion, participants watched one of two video demonstrations of the reward being extracted from the GCB. These clips were identical regardless of the model’s characteristic and counterbalanced across conditions; the only difference being

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in the depiction of different methods (method 1, poke-bolts-then-slide-door, and method 2, drag-bolts-then-lift-door). As participants had more than one response trial, there was a within-groups variable of trial number (T1 and T2). In the no-model control condition children were presented with the GCB without witnessing any demonstration.

2.4 Procedure

Children were tested individually in a quiet place in their school. Each child sat at a table in front of a laptop computer with the GCB on an adjoining table. The child was told "Today I have brought in this toy. This is a video of me showing the toy to Emma. Watch closely and listen carefully. "The child then watched an introduction to one of the video demonstrations in which the model walked into a room, looked at the GCB and turned to the camera professing either knowledge "I know this game, I've played with it lots of times, I know exactly how to do this" or ignorance "This is a new game, I have never seen it before, I don't know how to do it." Children watched this introduction twice and after each viewing were asked "Had Emma seen the game before? Did she know how to do it?" By the second viewing all participants answered correctly.

Then the child was told "We asked Emma to play with the box and recorded what happened." Following this, children watched one of two video demonstrations of a sequence of actions being carried out on the GCB, with either method 1 or method 2 being used. Unlike McGuigan et al. (2010), these latter video clips of demonstration showed only the hands and arms of a petite adult. Thus any difference in participant's behavior was due to model characteristics alone and not the physical differences in the demonstration (e.g. motor coordination) or ostensive cues. Twenty adults, blind to the study, watched the video clips. At the end they were asked who performed the actions.

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All labelled the demonstrations as desired, with those seeing a child at the beginning labelling the demonstration as having been performed by a child and those who witnessed an adult at the beginning attributing the actions to an adult.

The sequence of actions was as follows: the tool was used to remove two bolts on top of the GCB either by poking or dragging, the tool was inserted into the top hole and the glass ceiling tapped three times (totalling five irrelevant actions), a door at the front of the GCB was moved by either sliding or lifting it, the tool was inserted and a sticker removed. Children watched the video demonstration of the sequence of actions twice and were then told “I would like you to play with the toy. There is no right or wrong. I just want to see you play.” The child was allowed to interact with the GCB (T1) until (s)he retrieved the reward successfully or three minutes had elapsed. If required, children were given a prompt “You can play with it as much as you like.” Each child was then shown the demonstration clip a third time and allowed a further attempt (T2).

In the no-model condition each child was told “Lots of children have played with this toy today and now I would like you to play with it.” They received three minutes with the GCB and were given the same prompt as the experimental group. All children were rewarded with a sticker for their participation, regardless of the outcome.

2.5 Analysis

Each participant’s performance was scored on four variables, i) whether (s)he successfully removed the sticker, ii) whether (s)he opened the door and if so, the method used, iii) whether (s)he removed the ‘irrelevant’ bolts and if so, the method used and, iv) how many irrelevant actions were copied. The experimenter coded all children’s behavior

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whilst two independent observers, blind to the children's allocated condition, coded 26% of the sample. All Cronbach's Alpha scores were 0.96 or above, showing an excellent level of rater-reliability.

3. Results

The following analyses examined the level of success in obtaining the reward, fidelity to the method used for relevant (door opening) and irrelevant actions (bolt removal) and the number of irrelevant actions reproduced (out of five). All of these dependent variables were compared between participants (type of model) and within participants (T1 versus T2). Children who observed a demonstration were significantly more successful at retrieving the reward at T1 (success rate = 68%, $p< .005$ Fishers Exact Test, FET, one tailed) than children in the control condition (18%), with a significant increase in success from T1 to T2 (McNemar $Z_{1, 85} = -3.21$, $p < .001$).

3.1 Copying of causally relevant actions

No child in the no-model control condition lifted the door, while ten slid it. The number of children in the experimental conditions who copied the door-opening method they witnessed was significantly greater than chance with 78% copying the method at T1 $\chi^2(1, N = 60) = 26.67$, $p< .001$) and 76% at T2 $\chi^2(1, N = 74) = 13.84$, $p< .001$). Our first hypothesis was that model characteristics would not affect the copying of causally relevant actions. To test this we ran a multi-level logistic regression of relevant actions across T1 and T2 with corrected standard errors to account for the dependence between a child's T1 and T2 behavior. Model age, model knowledge state and demonstration witnessed (slide or lift) were the predictors and copying of action witnessed was the dependent variable. Age and knowledge state were not significant predictors of the

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imitation of the relevant method. Demonstration witnessed (lift or slide) was the only significant predictor (see Table 1). Children copied the door-slide method more than the door-lift method (97%copied slide, 51% lift).

Table 1 about here

3.2 Copying of causally irrelevant actions

Only two children in the control condition produced an action directed to the (causally irrelevant) bolts, both poking them, and none tapped the tool into the upper compartment. Thus, children who observed a demonstration performed significantly more irrelevant actions at T1 (M = 1.55, SD = 1.74, t_{34} = -1.28, p<.001) than control children (M = 0.27, SD = 0.65)[1]. In the experimental conditions, the number of children who copied the bolt removal method witnessed was significantly greater than chance at T1 χ^2 (1, N = 48) = 16.33, p< .001) and T2 χ^2 (1, N = 90) = 11.53, p< .002). As the bolt method witnessed did not affect the total number of irrelevant actions performed at T1 (t_{83} = -1.54, p = .13) or T2 (t_{83} = -1.61, p = .11) the data was collapsed across methods.

It was hypothesised that children would imitate more irrelevant actions when they were presented by an adult as opposed to a child and when presented by a self-reported knowledgeable model as opposed to an ignorant model. To test this we conducted a Poisson regression analysis of irrelevant actions, using joint modelling with robust standard errors to account for the dependence between a child's T1 and T2 behavior, with model age, model knowledge state, participant age and participant sex as predictors. Participant age and sex were not significant predictors. As expected model age was a significant predictor (adult model, M = 2.64, SD = 1.79, child model M = 1.79, SD =

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[1]Baseline behavior comparisons are made between the children in the control group and the experimental children at T1 only, as by T2 the children had experience with the GCB.

1.90, $p < 0.05$), but, contrary to expectation, knowledge state was not (see Table 2 and Figure 2). Thus, whilst children who witnessed an ignorant model produced fewer (M = 1.71, SD = 1.78) irrelevant actions than children who witnessed a knowledgeable model (M = 2.05, SD = 1.89, p = 0.18) this difference was not significant.

Insert Table 2 about here

Pairwise comparisons of the four conditions (1. knowledgeable adult, 2.knowledgeable child, 3. ignorant adult, 4. ignorant child) showed that whilst children presented with the child-ignorant model performed significantly fewer irrelevant actions compared to children presented with the adult-knowledgeable model ($t_{78} = -2.55$, $p < .05$), no other differences were significant (see Figure 2)

Insert Figure 2 about here

Post-hoc analysis

Overall children produced significantly more irrelevant actions at T2 (M = 2.21 SD = 1.89) than T1 (M = 1.55, SD = 1.74; $t_{84} = -3.71$, $p < .001$). This increase was significant for those who observed a knowledgeable adult (paired t-test: $t_{19} = -2.53$, $p < .05$, $d = 0.56$), and a knowledgeable child ($t_{22} = -2.08$, $p < .05$, $d = 0.40$) but not for those who observed an ignorant adult ($t_{21} = -1.87$, $p = .076$, $d = 0.28$), or an ignorant child ($t_{19} = -0.98$, $p = .34$, $d = 0.28$, see Figure 2), although the power for the latter two tests was low.

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4. Discussion

The current study extends research into cultural transmission by explicitly examining the role of, and relation between, two different model-based context dependent transmission biases: age and professed task-knowledge state. The results confirmed two of our initial predictions, (1) that children would imitate relevant actions regardless of a model's age and knowledge state, and (2) that children would imitate more causally irrelevant actions produced by an adult than a peer. Our third and fourth predictions, (3) that children would use a task-directed bias to imitate irrelevant actions produced by a task-knowledgeable, but not task-ignorant, model and (4) that there would be a hierarchy of transmission biases, received comparatively weaker support.

As predicted, and in line with previous findings (Flynn & Whiten 2008a, 2008b; Hanna & Meltzoff 1993; Hopper, et al., 2008, 2010), the model's characteristics did not affect the high levels of imitation of the relevant actions. Such faithful imitation of relevant actions appears to be 'canalisation', where the various possibilities for manipulating a task are reduced after a social demonstration (Flynn & Whiten, 2008b; Hopper et al., 2010; Horner, et al., 2006). This is clearly illustrated by the 46% of children who observed the door of the GCB being lifted and produced a lift action despite the availability of a preferred more salient slide method.

We posit that young children exhibit a social learning strategy (Laland, 2004) of '*faithfully* copy adults' as although they faithfully copied relevant actions from both peers and adults, they copied significantly more irrelevant actions when demonstrated by an adult versus a peer. The demonstrations were presented on video, and all children

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witnessed the same pair of hands manipulating the task, regardless of condition, so the bias we witness for children to copy an adult over a peer was not due to any ostensive cues present in the demonstration. Such a finding is in line with McGuigan et al. (2010) who found similar results with three- and five-year-old children. In contrast to Mesoudi & O'Brien's (2009) findings where a 'wholesale copy all' model-based bias including neutral irrelevant actions was found, the irrelevant actions in the current study entailed a cost, in terms of delaying reward acquisition. This demonstrates the potential power of such transmission biases to establish maladaptive information cascades, sometimes at the population level (Bikhchandani et al., 1998; Henrich & McElreath, 2003).

A task-directed bias of 'copy task-knowledgeable individuals' did not override the tendency to copy adults, despite the fact that the children in the current study could correctly identify the model's knowledge state. In contrast, when Brody & Stoneman, (1985) juxtaposed peer age and competence (on an unrelated task), a competence bias outweighed any age bias, such that younger peer/high-competence models were preferred over same-age peers/low competence ones. Whether this difference in results is due to the model's ages (adult and child model versus younger and same age peer model), reputation (knowledge state versus reliability) or medium of competency (self-declared in a video clip versus a description given by an adult experimenter) are unclear but seem ripe for further exploration.

Whilst the regression model of irrelevant actions indicated that knowledge state was not a significant predictor the pairwise comparisons of all four model types (knowledgeable adult, ignorant adult, knowledgeable child, ignorant child) showed that a knowledgeable adult was copied significantly more than an ignorant child, but there were

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no other significant differences between the four model types. Thus model age was weighted over professed task-knowledge, but task-knowledge was evaluated to some degree, lending some support to the idea that there is a hierarchy of transmission biases as reported by McElreath et al. (2008). Additionally post hoc analysis revealed that children who witnessed knowledgeable models regardless of age, reproduced significantly more irrelevant actions at their second attempt, than children witnessing ignorant models, who showed no change across their attempts. Taken together these results provide limited support for a knowledge-based strategy.

Our findings provide, to our knowledge, the first evidence in any species (consistent with the analogous prediction of Laland, 2004) that easily adopted heuristics, such as age-based biases, may be more readily used in decisions pertaining to the cultural transmission of information, than more cognitively challenging biases, such as those involving assessment of another’s knowledge state with regard to the task at hand. The question then is, whether an age bias is inherently more adaptive than a knowledge state bias or whether it is simply easier to evaluate? Whilst there is an argument that children may understand that self-declared knowledge states may be less reliable than age we believe it is more likely that the preference for a ‘copy adult over child’ strategy (Dugatkin & Godin, 1993) involves less cognitive processing and is a by-product of its relative ease to implement. An understanding of age develops earlier than an understanding of knowledge (Edwards 1984; Wellman et al., 2001) and thus related biases may also develop earlier.

This cognitively ‘lighter’ assessment of a model’s age may, however in itself, be adaptive because adults, by their increased experience with the world, are generally more

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proficient and knowledgeable models than children. Research has shown that children infer a model's knowledge state based on his/her age (Taylor et al., 1991). Thus this correlation may lead to effective social learning strategies. However, when the correlation is contradicted, and there are instances of ignorant adults or knowledgeable children, children still rely on the age bias resulting in the current study's finding that children are as likely to copy the irrelevant actions of an ignorant adult as a knowledgeable child. This occurs even when, as happened in the current study, every child is able to correctly identify the knowledge state of the model. To investigate these claims further it would be wise to conduct future research into children's developing ideas of the inter-relation between age and knowledge state.

The relation between these biases also helps us to understand the phenomena of copying causally irrelevant actions. Children's selective reproduction of causally irrelevant actions suggests that this phenomenon may not be as pervasive as previously thought (Lyons et al., 2007; Nielsen & Tomaselli, 2010) in that the replication of irrelevant actions was modulated in response to a model's characteristics. However, that is not to say that imitation of irrelevant actions can no longer be considered an evolutionary adaptation (Nielsen & Tomaselli, 2010). The copying of causally irrelevant actions may reflect a cognitively complex process within a child, involving assumptions about the 'irrelevance' of particular actions. For example, it would be adaptive for children to evaluate which seemingly causally irrelevant actions may be relevant actions whose causal efficacy they are yet to understand (Hernik & Csibra, 2009) versus those actions which are simply irrelevant. A wise assumption may be that adults are more likely to produce 'irrelevant' actions that actually have an opaque function, perhaps that of social or cultural relevance, whilst irrelevant actions from peer-aged children should

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be taken at face value. Therefore an overriding strategy of ‘adults should be imitated faithfully, children should be imitated unless their actions seem non-functional’ may be extremely beneficial, even though this heuristic may sometimes lead to the copying of irrelevant actions.

High fidelity copying is a necessary factor underlying the unique capacity of humans for cumulative cultural transmission (Boyd & Richerson, 1985). Faithful imitation is the bedrock of cultural ratcheting (Tomasello, 1999) as such a phenomenon prevents any loss of knowledge, allowing for potential improvement in subsequent individual development and/or generations. Faithful imitation of causally irrelevant actions, as exhibited in this study, may appear to conflict with our species' capacity for cumulative culture due to its potential to lead to cascades of misinformation. However, the current study has demonstrated that the selective nature of children’s social learning, in copying adults over children and potentially assessing the irrelevance of apparently causally irrelevant actions, explains why a more likely result is the advancement of complex, socially learned behaviors.

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Figures

Figure 1. The Glass Ceiling Box (GCB) showing model performing one of the irrelevant actions. Photo from Flynn (2008)

Figure 2. Mean number of irrelevant actions (out of ten) performed depending on model identity over the two trials. Asterisks indicate a difference in means more than expected between groups (* $p < .05$). * within a bar indicates a significant increase in irrelevant actions from T1 to T2 ($p < .05$).

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