Robust, source-independent biases in children's use of socially and individually acquired information

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Abstract

Culture has an extraordinary influence on human behaviour, unparalleled in other species. Some theories propose that humans possess learning mechanisms biologically selected specifically for social learning, which function to promote rapid enculturation. If true, it follows that information acquired via observation of another's activity might be responded to differently, compared with equivalent information acquired through one's own exploration, and that this should be the case in even very young children. To investigate this, we compared children's responses to information acquired either socially, or from personal experience. The task we used allowed direct comparison between these alternative information sources, as the information value was equivalent across conditions, which has not been true of previous methods used to tackle similar questions. Across two 18mo-5yo samples (recruited in the UK and China) we found that children performed similarly following information acquired from social demonstrations, compared with personal experience. Children's use of the information thus appeared independent of source. Furthermore, children's suboptimal performance showed evidence of a consistent bias driven by motivation for exploration as well as exploitation, which was apparent across both conditions and in both samples. Our results are consistent with the view that apparent peculiarities identified in human social information use could be developmental outcomes of general-purpose learning and motivational biases, as opposed to mechanisms that have been biologically selected specifically for the acquisition of cultural information.

Keywords— social learning; cumulative cultural evolution; learning mechanisms; human behaviour; child development

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1 Introduction

Much of human behaviour (including basic survival skills, e.g. Henrich and McElreath, 2003) is dependent on cumulative cultural evolution, a process of cultural change which produces traits that are increasingly functional and advantageous to their users (Tomasello et al., 1993; Tomasello, 1999; Caldwell and Millen, 2008). Cumulative culture is pervasive across all human societies, yet is widely regarded as being absent in other species (e.g. Tennie et al., 2009; Dean et al., 2014; though see Laland and Hoppitt, 2003; Mesoudi and Thornton, 2018; Caldwell et al., 2020 for discussion of how some examples of non-human culture have been considered cumulative). Identifying the reasons for this apparently unique human capacity has been the focus of a substantial body of research. Proposed explanations have included humans having a unique set of socio-cognitive abilities (Dean et al., 2012, 2014), or they have considered the importance of potentially species-unique factors such as high-fidelity copying (Horner and Whiten, 2005; Lyons et al., 2007; Whiten et al., 2009) and explicit metacognition (Shea et al., 2014; Dunstone and Caldwell, 2018), amongst others.

A focus on humans' extraordinary dependence on cultural inputs, and the distinctive elaborateness of human cultural traits, has led many theorists to suggest — or, as noted by Heyes (2012b), to appear to simply assume — that human social learning is distinct from human asocial, or individual, learning. That is, that there may be biologically-selected social-learning-specific mechanisms (e.g. Meltzoff, 1988, 1999; Tomasello, 1999; Herrmann et al., 2007; McGuigan et al., 2007; Hill et al., 2009; Tennie et al., 2009; Whiten, 2011; Dean et al., 2014; Henrich, 2016; Tennie et al., 2016). These function to concentrate naive minds on the abundance of social information that surrounds them, promoting rapid enculturation.

Humans' adept use of social information and the acquisition of species-specific cultural content may have been (at least in part) selected due to the fitness advantages that these convey. For example, prioritising social information will be advantageous where social information is quantifiably more useful or important relative to direct personal experience, which will particularly be the case for certain types of cultural trait such as tool or language use, or in cases where direct personal experience is more risky to obtain. And in the case of some cultural traits, such as cultural norms and rituals, information available from others' activity or instruction may be the only means by which they can be acquired. The nature of this selection, and the extent to which it is a biological selection process as opposed to being an outcome of a person's development (see, e.g., Barrett, 2019, for discussion), however, is not yet clear. Any special status granted to social information could therefore arise for different reasons. Toward one end of a continuum it could be largely *independent* of experience, in the way that, for example, smiling (which is even present in blind babies; Freedman, 1964; Valente et al., 2018) and social tolerance develop with little or no input (see Heyes, 2018, 2019, for review and discussion). Toward the other end of the continuum, special treatment of social information could be relatively experience-*dependent*, as, for example, literacy is (Heyes and Frith, 2014). However, many theorists suggest, or assume, that there are social-learning-specific processes for learning from others, functioning to promote rapid enculturation, which are present from birth (Tomasello, 1999; Tennie et al., 2009; Dean et al., 2014; Henrich, 2016; Tennie et al., 2016), i.e. that are, at least relatively, *independent* of a person's experience.

If there are social-learning-specific processes, then it follows that information acquired via observation of another's activity might be responded to differently, compared with equivalent information acquired through one's own exploration. Studies involving human adults have indeed suggested differences in the treatment of information dependent on its source, with greater weight being given to information acquired through personal experience at the expense of making full use of available social information (e.g. McElreath et al., 2005; Efferson et al., 2007; Eriksson and Strimling, 2009; Novaes Tump et al., 2018). However, identifying differences in individual and social information use in adults does not tell us the age at which such differences emerge. If there are social-learning-specific responses which are relatively independent of an individual's experience (i.e. they would be present even with only limited social and asocial learning), then a different treatment of social, relative to individual, information should be evident in even very young children. Alternatively, if social-learning-specific responses are more experience dependent, then different treatment of information acquired socially and individually should be less evident in younger children, but should develop with age.

This raises the question of whether young children do respond to social inputs in fundamentally different ways, relative to information obtained through their own direct personal experience, and if they do, at what age this specialisation develops. To test this, it is crucial to compare treatment of social and individual information when the value of the information obtained is equivalent, i.e. when the only difference in the information is its source. Human social learning has been characterised as a "high fidelity" transmission process, in this respect distinct from lower resolution social influence observed in other species (e.g. Tennie et al., 2009). It has also been proposed that high-fidelity copying may represent a functional adaptation, selected for the ability to accelerate the transmission of potentially beneficial, but causally opaque, cultural traits (e.g. Herrmann et al., 2007; Lyons et al., 2007; Whiten et al., 2009). Yet do children repeat socially learned behaviours with more "high fidelity" than they repeat those they learn through personal exploration? There is also the question of whether children are particularly attentive to social information, and able to learn from it as proficiently (or possibly even more so) as they do from their own experience. These are fundamental predictions which remain untested in the literature, yet examining young children's treatment of equivalent social and individual information has the potential to shed light on the extent to which the apparent peculiarities of human social information use are relatively experience independent or experience dependent.

Comparison of children's responses to equivalent information acquired either socially or from personal experience is virtually impossible to address using the standard methodological approaches employed in the study of children's social learning (e.g. puzzle-box apparatuses, or tool-use tasks, e.g. Lyons et al., 2007; Nielsen and Tomaselli, 2010; Flynn et al., 2016) in which possible solutions are necessarily constrained by the physical structure, and what is learned is generalisable information which would apply across multiple encounters with the same object, as well as others similar to it. This means that even if participants have not encountered a specific apparatus before, it is not possible to control for their baseline expectations about correct or appropriate responses, nor is it possible to assume that information from a social source, or from personal experience, should be equally weighted. Children's prior experience with similar objects will influence the strength of their expectations about possible responses and their likely effectiveness, and therefore the extent to which they respond to personal feedback. In addition, their prior experience of imitating others' actions in similar contexts will influence the extent to which they take into account the apparent effects of another's actions within the experimental paradigm (e.g. the child is likely to have experienced positive consequences associated with copying others' actions even when the effect or purpose of the action may have been opaque). Therefore, in relation to the likelihood of repeating actions that do not directly produce a desired outcome (or indeed those that do), a fair comparison cannot usually be made between the effect of learning this via personal experience versus a social demonstration.

Furthermore, although children will bring different expectations to any experimental task regarding the value of information from a social source compared with their own exploration (and past experience means they are likely to, regardless of the task in question), in these standard methodological paradigms it is not possible to systematically study the extent to which new experiences update weightings assigned to these expectations. Since what is learned is generalisable knowledge, updating from the carry-over of experiences themselves (i.e. effective and ineffective responses) cannot easily be separated from updating of the strategy (i.e. when to copy or persist with responses observed or attempted previously, and when to deviate from these). Indeed, within methodological paradigms which involve learning how to operate physical apparatuses, there is generally no way of specifying a categorical and finite set of possible responses that might be performed, since these are continuous, and the problem space itself is ill-defined. This makes it difficult to equate the information value available from observing or experiencing a response that generates a desirable outcome, from one that appears not to do so. An action seen to produce a desirable outcome might well be expected to be repeated, and at a higher rate than would be expected given no such experience. However, it does not follow that an action with a more ambiguous outcome should be avoided, or indeed how to quantify the possible alternatives and their respective baseline probabilities.

In this study we therefore use an abstract stimulus choice task, for which information acquired personally or socially was only episodic, that is, specific to a particular problem (i.e. particular set of stimuli), with the critical test trial occurring directly after the initial information trial. The reward structure is explicit, with the reward arbitrarily assigned to one of the response options. The predictive relationship between the information trial and test trial is also consistent. Therefore, assuming participants have understood or been able to learn this task structure, in a binary choice the information trial (whether rewarded or unrewarded) provides unambiguous information about the location of the reward. The task also allows us to directly manipulate the baseline probability of making a particular response over the possible alternatives simply by varying the number of stimuli, and therefore the potential responses. This allows us to investigate the generalisability of response patterns, in determining whether a particular response pattern is carried over from one version of the task (such as the binary choice task in Stage A of Experiments 1–2 described below) to another (such as the three-stimulus choice task in Stage B of Experiments 1–2). Finally, since the stimuli are arbitrary, and the reward location is randomly assigned, multiple problems can be presented to the same participant, as any carry-over effects linked to the structure of the stimuli themselves (e.g. same side, or similar shape or colour as another previously associated – or not – with a reward) should have no systematic influence on the child's likelihood of selecting one of the responses over another. Thus we can study the effect of repeated experience of multiple problems on learning the optimal response strategy (i.e. win-stay, lose-shift for Experiments 1–2, although c.f. Experiment 3).

Discrimination learning tasks such as the one we use here have been widely used in comparative as well as developmental psychology, and have provided evidence of the formation of learning sets in children and nonhuman primates (e.g. Harlow, 1949; Levinson and Reese, 1967). Studies of preschool children have thus far focused on learning from personal experience only (information trial and test trial both completed by the participant), but these indicate that children can successfully apply a win-stay, lose-shift rule, and show improved performance with increasing task experience. In the experiments reported here, we directly compare the test trial performance of children who made their own information trial selections with the performance of those who observed information trials performed by the experimenter. Thus we exploit the fact that the information trial always provides definitive, but problem-specific, information about reward location, as a means to compare the efficacy of use of social and individual information when these have directly (and transparently) equivalent predictive value.

Our experimental manipulation therefore is the *source* of the information, with the context of acquisition and the predictive value of that information equivalent in each condition. In keeping everything constant except for the *source of the information*, note that both of our conditions involve the child learning in a *context* that is social: in both cases the child is presented with the task by a researcher in a social setting. Nevertheless, there are fundamental differences between the conditions which we may expect to lead to different patterns of behaviour if social-learning-specific responses are relatively experience independent. In the Individual condition, it is the child who chooses which of the stimuli to select in the information trial, and the child who physically makes, and receives direct feedback on, that selection. In the Social condition, the child cannot influence which stimulus is selected in the information trial, and they passively observe the selection being made by the researcher; instead of receiving direct feedback, they receive vicarious observation of another's feedback. If the source of information influences a child's use of that information, as we may predict if social-learning-specific responses are relatively independent of experience, then there are a number of ways we may see evidence for it in our experimental results. Firstly, children's performance may be better overall in one condition over the other, i.e. they may (in Experiments 1–2) behave more in accordance with a win-stay, lose-shift strategy and locate the reward more often in the test trial in either the Social or Individual condition. If specific processes which focus children specifically on social information are relatively experience independent, then task success may be greater in the Social condition overall in even the youngest children. Secondly, if young children possess mechanisms, serving to promote the rapid acquisition of potentially opaque traits, which lead to a tendency to specifically copy other individuals with relatively high fidelity, then we may see a greater tendency to repeat the information trial selections in the Social condition relative to the Individual condition. We may see evidence of this overall, i.e. greater repetition of the information trial selection in the Social condition relative to the Individual condition regardless of whether the information trial was rewarded (more win-stay behaviour) or unrewarded (more lose-stay behaviour).

Alternatively, a greater tendency to repeat the information trial selection in the Social condition may be conditional on the type of information trial selection, i.e. there may be a greater amount of repetition following rewarded information trials in the Social condition relative to the Individual condition, but not following unrewarded information trials, or vice versa. Thirdly, we may see evidence for changes in the relative responses to Social or Individual information trials over the course of the experiment. If children do respond to information differently dependent on its source, then we may see overall task success increase with task experience in one condition to a greater extent than the other. Finally, we may see effects of child age, with differential use of information acquired socially versus individually affected by experience. If social-learning-specific processes employed for learning from social sources are more experience dependent, then we may see stronger evidence of any condition-specific biases in the Social condition compared to the Individual condition to a greater extent in the older children.

2 Experiment 1: Children's use of socially and individually acquired information (UK)

2.1 Methods

Each child was allocated to either the Individual or Social condition, and completed a series of problems over two stages (A and B).

In Stage A, there were up to 10 problems, each a binary discrimination task consisting of an information trial (IT) and a test trial (TT). Across both trials for a particular problem, the same pair of two simple geometric stimuli were presented. An example problem is illustrated in Figure 1.

In the IT in the **Individual condition**, the child would select one of the two stimuli, and the selection would be revealed to the child as either unrewarded or rewarded. Of the 10 possible problems, five were rewarded and five unrewarded, in a randomised order. Following an unrewarded selection, both stimuli were removed for 2 seconds. Following a rewarded selection, both stimuli were removed, with the selected stimulus replaced by an image of a cartoon monkey for 2 seconds, accompanied by a recording of a chimpanzee vocalisation.

The IT was then immediately followed by the TT. The same two stimuli were presented in the same positions, and the child was encouraged to select the stimulus which would reveal the monkey. The position of the monkey was always the same as in the IT, so following a rewarded IT, the optimal response

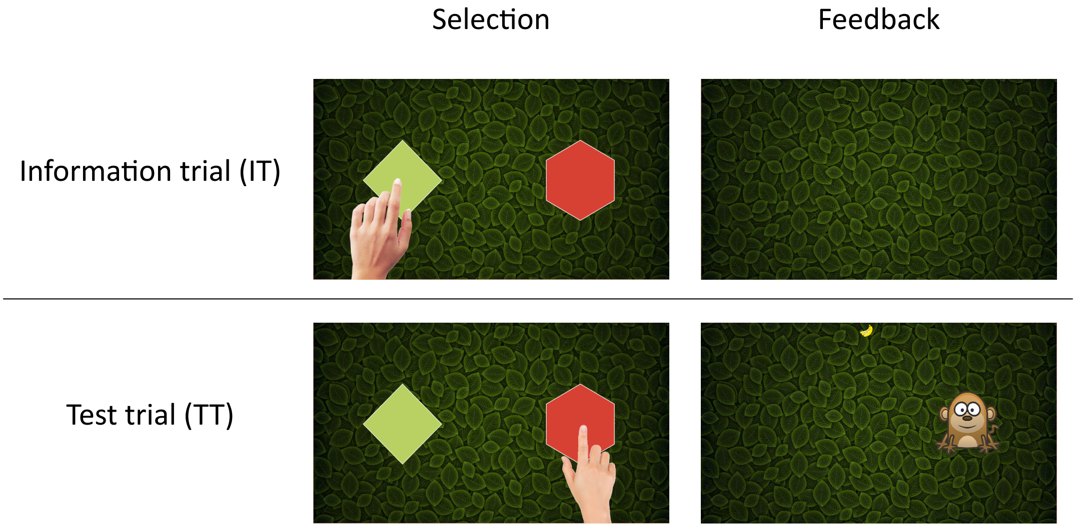

Figure 1: **Example Stage A problem.** In the IT, the child is shown two stimuli and one of these is selected, by either the child (Individual condition) or the experimenter (Social condition; illustrated above with the top hand being the researcher's and the bottom being the child's). Here, the left stimulus is selected, and is unrewarded. In the TT, the child is shown the same two stimuli in the same positions, and encouraged to select the rewarded stimulus. Here, they lose-shift, select the rewarded stimulus, and reveal the reward. The banana at the top of the screen indicates that they now have a running score of 1 consecutively rewarded TT. The hands shown here are for illustration purposes only.

would be to select the same stimulus; following an unrewarded IT, to select the alternative stimulus, and a correct selection would again reveal the monkey with the accompanying recording. Stage A ended after 10 problems or (to maintain engagement in children who demonstrated high proficiency) after five consecutive successful TTs.

Stage B followed the same procedure as Stage A, except it was a three-way discrimination task, with the three stimuli placed on the left, centre, and right side of the screen. As discussed above, increasing the number of stimuli in this way allowed us to investigate any changes in the response patterns when the number of potential responses was varied. As before, the monkey was always in the same position in the TT as it was in the IT for each problem. Following a rewarded IT, the correct response would be to select the same stimulus (win-stay), which would always reveal the monkey (as in Stage A). Following an unrewarded IT, the correct response would be to select one of the two alternative stimuli (lose-shift), and so the participant would have a 50% chance of finding the monkey. Children completed 10 problems regardless of how many TTs were rewarded consecutively. As before, five of the ITs were rewarded and five unrewarded, in a randomised order.

In the **Social condition**, the procedure was the same, except the experimenter, rather than the participant, made the selection in the IT. The stimulus selected in each case was determined by a randomly generated list. As with the Individual condition, of the 10 possible problems, five were rewarded and five unrewarded, in a randomised order.

See SI 4 for additional methodological details.

To assess the effects of task experience on optimal use of the IT cues, we analysed “task success” (encompassing both re-selection of a stimulus following a rewarded IT, and selection of an alternative stimulus following an unrewarded IT) during Stage A problems. To investigate the fidelity with which children reproduced an IT selection, we compared “repeats” (including all re-selections of stimuli selected during the IT) across Stages A and B.

Note that we did not preregister any predictions for Experiments 1–2 (our research group only began to preregister studies as a matter of course at a time when the first two experiments had already been completed). We did, however, make two key predictions. Firstly, we predicted that task success would increase with age and with problem number. Secondly, we expected that any different treatment of information dependent on its source would be relatively experience-dependent, and so we anticipated that if there were any differences in task success or repeating behaviour between our conditions, they would become increasingly evident with age. We made no directional predictions in respect of source effects, however.

2.2 Participants

We collected data from 172 children aged 5 and under in Glasgow, UK. See SI 4 for additional details of the data collection and a full breakdown of participants by age and population (alongside those for Experiments 2–3). The ethical approaches of this study were reviewed and granted approval by the General University Ethics Panel of the University of Stirling.

2.3 Results

The analyses we report throughout are planned analyses, unless explicitly stated otherwise. Both success and repeats measures were binary coded: a successful TT was 1, and 0 otherwise; a TT repeat was 1, and 0 otherwise.

In the first analysis, we investigated how task success varied with problem number, and the interaction between problem number and source, and also how task success was influenced by source, information type, age, and their interactions. Of the 172 children, 41 (24%) located the reward in each of the first five problems of Stage A, and so completed no further Stage A problems (see SI 2.1.1 for more details). For between-subject comparison purposes therefore, our analysis of task success considered only the first five problems of Stage A, which are illustrated in Figure 2 alongside proportion repeats and the results of Experiments 2-3. Analysis of success in Stage B is in SI 2.1.2, and an illustration of repeats for all the Stage A and B data is in SI 1.

All analyses involved generalised linear mixed effects models with logit link using R (R Core Team, 2013) and *lme4* (Bates et al., 2013), taking p-values < .05 as statistically significant. Where significant interaction terms involving source and age were indicated, we investigated the effect of source on the younger (under 4 years old) and older (4 and over) children post hoc, by repeating our analysis on the two subsets of the data separately. Model details for all analyses of Experiments 1–3 are given in SI 2.

2.3.1 Task success

Task success was above chance (M = 0.73, SD = 0.21, $p < .001$; see SI Table 1, SI 2.1.1). In the Individual condition, average task success was 0.55 (SD = 0.38) following rewarded ITs and 0.90 (SD = 0.24) following unrewarded ITs. In the Social condition, average task success was 0.56 (SD = 0.38) following rewarded ITs and 0.89 (SD = 0.24) following unrewarded ITs.

There was no evidence of an overall effect of source ($p = .519$). Task success was greater following unrewarded ITs compared to rewarded ITs ($p < .001$), and this was more pronounced in older children (information type x age interaction: $p < .001$). Success increased with problem number ($p = .001$) and with age ($p < .001$). There was an interaction effect between source and age indicating that the effect of age was more pronounced in the Individual condition ($p = .016$). There were no other significant interaction terms ($p \geq .295$).

We followed up the source by age interaction by rerunning our analysis within each of the younger and older age groups (see SI Figure 2 for illustration of mean task success by age group and source). Although the trends were in opposite directions, the effect of source was not significant in either the younger ($p = .171$; SI Table 2) or older ($p = .061$; SI Table 3) children. There were no interactions involving source in either subset ($p \geq .217$).

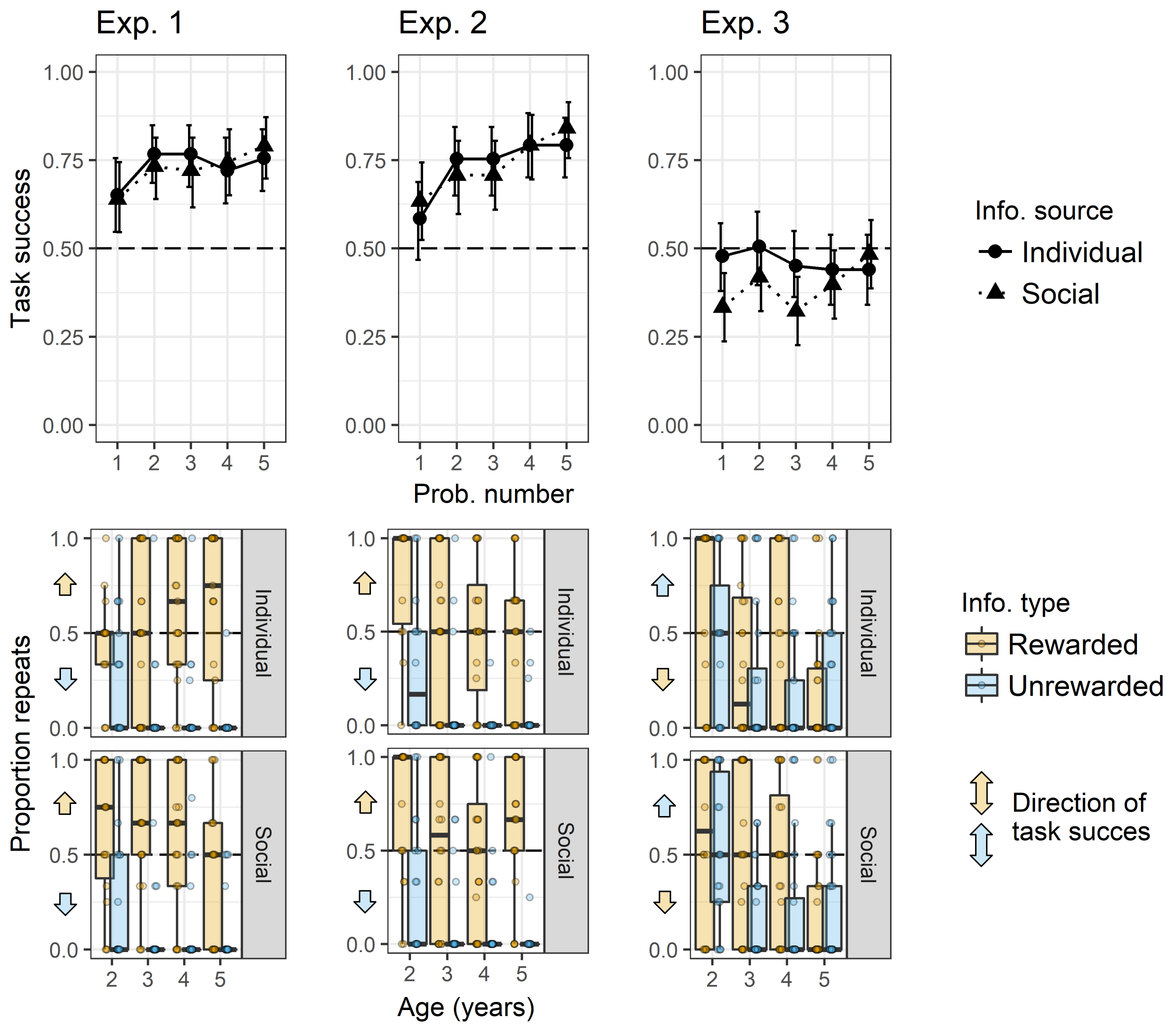

Figure 2: **Task success by source and problem number (top row) and proportion of repeats by age (whole years) and information type (bottom row) for Problems 1–5 of Stage A for Experiments 1–3.** Task success error bars are 95% confidence intervals. Proportion repeats arrows indicate whether repeats or non-repeats increase task success for a given experiment and information type: for Experiments 1–2, repeats following rewarded ITs increase task success, while non-repeats following unrewarded ITs increase task success; this pattern is reversed for Experiment 3. For ease of comparison between task success and repeats, both plots are based only on Stage A Problems 1–-5, although the statistical analysis of repeats was based on the entire data set of all Stage A and B problems. See SI 1 for proportion of repeats for the entire data set. Dashed lines indicate chance performance.

2.3.2 Repeats

In the second analysis, we investigated how the likelihood of repeating the IT selection in the TT was influenced by information type, stage, age, and source, and all interactions. This analysis was based on our entire dataset of all Stage A and B problems.

Overall, the proportion of repeats was 0.35 (SD = 0.17). In the Individual condition, average proportion of repeats was 0.65 (SD = 0.29) following rewarded ITs and 0.09 (SD = 0.17) following unrewarded ITs. In the Social condition, average proportion of repeats was 0.60 (SD = 0.31) following rewarded ITs and 0.08 (SD = 0.15) following unrewarded ITs.

There was no evidence of an overall effect of source ($p = .454$; SI Table 5). Children's overall rates of repetition were not significantly different between Stage A (M = 0.35, SD = 0.21) and Stage B (M = 0.36, SD = 0.18, $p = .739$). This is in spite of the chance-level probability of repeating an IT selection in the TT being different between Stages A and B (50% vs. 33%). There were more repeats following rewarded ITs (Stage A: M = 0.62, SD = 0.33; Stage B: M = 0.65, SD = 0.33) compared to unrewarded ITs (Stage A: M = 0.09, SD = 0.19; Stage B: M = 0.07, SD = 0.17, $p < .001$).

Older children repeated less overall than younger ($p < .001$), and this effect was more pronounced following unrewarded ITs (information type x age interaction: $p < .001$). There were no two-way interactions involving source ($p \geq .202$), although there was a three-way interaction involving source, information type, and age ($p = .048$), consistent with the source by age interaction on task success (reported above). Once again we followed up this interaction involving source and age by rerunning our models on both the younger and older age groups (see SI Figure 3). In the younger group, there was no main effect of source ($p = .602$; SI Table 6) and no interaction involving source ($p \geq .055$). In the older group, there was again no main effect of source ($p = .561$; SI Table 7), but there was a significant interaction between source and information type ($p = .021$). Again in line with our task success analysis, this indicates that the increased tendency to repeat following rewarded ITs relative to unrewarded ITs was more pronounced in the Individual condition in this age group. There were no other interactions involving source ($p \geq .453$).

2.4 Discussion

We found no evidence of any difference in overall success rates between the Social and Individual conditions. And although success rates were higher for later problems, there was also no evidence that this strategy-learning effect was any stronger for one condition over another. Overall, children's TT performance was above chance, regardless of the source and type of information to which they were exposed. They tended to repeat rewarded responses, and deviate from those that had been unrewarded, regardless of whether the information was acquired socially or individually. Children were more likely to deviate from unrewarded responses than they were to repeat rewarded ones. This was true across the full age range, and in both the Social and Individual conditions. We return to this bias and test a possible explanation for its prevalence in Experiment 3. Performance on three-way discrimination problems (presented after the two-way discrimination problems) was also well above chance, and the tendency to repeat rewarded selections, and avoid unrewarded selections, did not appear to be influenced in line with the change in corresponding chance levels (33% vs. 50% for chance-level repetition). Although this suggested that information was being used in a relatively "high fidelity" manner, this effect was again common to both the Social and Individual conditions. Overall therefore we found little evidence of children responding differently to information acquired from a social source compared with that acquired individually. The patterns of performance we observed (which included remarkably consistent patterns of below-ceiling performance in apparently task-competent individuals) did not appear to reflect a specific social learning strategy, but more general learning and motivational biases (see Section 5). Finally, children's overall success rates increased with age, and there were also weak interaction effects: the age effect was more pronounced in the Individual condition, suggesting that relative performance in response to individual and social information might change with age. We return to this point below in Section 3.

3 Experiment 2: Children's use of socially and individually acquired information (China)

Experiment 1's results may reflect a real, generalisable, equivalence in how children respond to information acquired socially and individually, once potential confounding factors are stripped away (see above). However, an absence of noteworthy differences in a specific sample provides only weak support for the conclusion that social and individual information are treated in similar ways, particularly if we hope to draw more general conclusions about children's learning that extend beyond this sample. In a study carried out across seven different societies, for example, cross-cultural variation was found in children's rates of repetition of demonstrated actions, versus an alternative, non-demonstrated, response (van Leeuwen et al., 2018). This study considered only socially acquired information, however, so it is not clear whether these cultural differences reflected variation in dependence on social information specifically, or preferences for novelty or exploration not restricted to social learning contexts. Previous work has also suggested that societies characterised by the prevalence of particular attitudes and cognitive styles may show associated patterns in the relative reliance placed on information acquired from social versus individual sources (Mesoudi et al., 2015; Glowacki and Molleman, 2017; Triandis, 1995; Triandis and Gelfand, 1998; Gelfand et al., 2011). Past literature has focused in particular on distinctions in individualism/independence versus collectivism/interdependence (e.g. Triandis, 1995), but other dimensions have also been found to differentiate societies in significant ways that might be expected to impact on the importance placed on information acquired socially (e.g. horizontal/vertical, Triandis and Gelfand, 1998; and tight/loose, Gelfand et al., 2011). We therefore attempted to replicate our results from Experiment 1 using a sample of participants from China, a population of particular interest for a number of reasons. Firstly, it was important to extend the research beyond populations typically sampled in human behavioural research (as stressed by Henrich et al., 2010; Nielsen et al., 2017). Secondly, adults from China had already been reported to make greater use of social information, relative to participants from the UK, in an experimental task (Mesoudi et al., 2015). Finally, Chinese society is generally described as being more "collectivist"/"interdependent" than the UK (Triandis, 1995), as well as scoring higher for "tightness" in relation to the importance placed on social norms (Gelfand et al., 2011).

3.1 Methods

Our methodology was the same as that of Experiment 1. We anticipated a pattern of results which replicated those of Experiment 1, i.e. that our results would be independent of sample (as noted above, we did not preregister any predictions).

3.2 Participants

We recruited 159 children aged 5 and under in Beijing, China (see SI 4 for details). The ethical approaches of this study were reviewed and granted approval by the Committee for Protecting Human and Animal Subjects, School of Psychological and Cognitive Sciences, Peking University.

3.3 Results

Of the 159 children, 40 (25%) located the reward in each of the first five problems of Stage A, and so completed no further Stage A problems (see SI 2.2.1 for more details).

3.3.1 Task success

As in Experiment 1, our analysis of task success considered only Problems 1–5 of Stage A (see SI 2.2.2 for analysis of Stage B).

Task success was above chance (M = 0.73, SD = 0.22, $p < .001$; SI Table 8). In the Individual condition, average task success was 0.55 (SD = 0.39) following rewarded ITs and 0.89 (SD = 0.25) following unrewarded ITs. In the Social condition, average task success was 0.57 (SD = 0.39) following rewarded ITs and 0.88 (SD = 0.26) following unrewarded ITs.

Replicating the key findings from Experiment 1, there was no overall effect of source ($p = .999$). Task success was greater following unrewarded ITs compared to rewarded ITs ($p < .001$), and this was more pronounced in older children (information type x age: $p < .001$). Success increased with problem number ($p < .001$) and with age ($p = .012$). Unlike Experiment 1, there was no significant interaction between source and age ($p = .369$).

To investigate any differences in task success between the UK and China samples of children, we combined the Stage A problems 1–5 datasets for Experiments 1–2 and repeated the analyses with population as an additional variable (SI 2.3.1).

There was no main effect of population ($p = .638$; SI Table 13). As in the previous analyses for Experiments 1–2, task success was above chance ($p < .001$). There was no main effect of source ($p = .605$). Task success was greater following unrewarded ITs compared to rewarded ITs ($p < .001$), and this was more pronounced in older children ($p < .001$). Performance improved with problem number ($p < .001$) and with age ($p < .001$).

There was a three-way interaction between source, age, and population ($p = .021$). We followed up this interaction by rerunning our models on both the younger and older age groups (see SI Figure 5). There was no main effect of source ($p \geq .558$; SI Tables 14 and 15) or any interactions involving source ($p \geq .072$) in either age group.

3.3.2 Repeats

As in Experiment 1, we also analysed the likelihood of repeating the IT selection in the TT for all problems in both stages.

Overall, the proportion of repeats was 0.37 (SD = 0.40). In the Individual condition, average proportion of repeats was 0.66 (SD = 0.34) following rewarded ITs and 0.06 (SD = 0.18) following unrewarded ITs. In the Social condition, average proportion of repeats was 0.65 (SD = 0.36) following rewarded ITs and 0.09 (SD = 0.22) following unrewarded ITs.

Consistent with the findings of Experiment 1, there was no evidence of an overall effect of source ($p = .701$; SI Table 12). Children's overall rates of repetition were not significantly different between Stage A (M = 0.36, SD = 0.24) compared with Stage B (M = 0.37, SD = 0.21, $p = .067$), despite the increase in stimuli. There were more repeats following rewarded ITs (Stage A: M = 0.62, SD = 0.34; Stage B: M = 0.69, SD = 0.36) compared to unrewarded ITs (Stage A: M = 0.10, SD = 0.22; Stage B: M = 0.06, SD = 0.18, $p < .001$).

Older children repeated less than younger ($p = .001$), and this effect was more pronounced following unrewarded information trials ($p < .001$). Unlike in Experiment 1, there was no three-way interaction involving source, information type, and age ($p = .057$).

As above, we combined the Experiment 1–2 datasets and repeated the analyses with population as an additional variable (SI 2.3.2).

There was no main effect of population ($p = .642$; SI Table 16). As in the previous analyses for Experiments 1–2, there was no main effect of source ($p = .577$). There were more repeats following rewarded ITs compared to unrewarded ITs ($p < .001$). Older children repeated less than younger ($p < .001$), and this effect was more pronounced following unrewarded ITs ($p < .001$).

Though not evident in the separate analyses of the Experiments 1–2 datasets, there were fewer repeats in Stage B relative to Stage A ($p = .032$), especially following unrewarded ITs (information type x stage $p < .001$); this was particularly the case in the older children (information type x stage x age: $p = .019$). Relative to the UK population, the greater number of repeats following rewarded ITs compared to unrewarded ITs was more pronounced in the China population (information type x population: $p = .008$).

There was also a four-way interaction between source, information type, population, and age ($p < .001$), consistent with the three-way (source x population x age) interaction reported for task success. We followed up this interaction by rerunning our models on the younger and older children separately (see

SI Figure 6). In the younger children, there was no effect of source (p = .613; SI Table 17), but there was a three-way interaction involving source (source x information type x population: p = .001). There were no other interaction effects involving source ($p \geq .074$). In the older children, there was again no effect of source (p = .979; SI Table 18), but there was the same three-way interaction involving source as for the younger children, though in the opposite direction (p = .035). There were no other interactions involving source ($p \geq .216$).

To further investigate the effects of source, information type, population, and age, we considered each age group within each population separately, and repeated our analysis. For the UK data, these unplanned analyses are those reported in Section 2.3.2, above. In the younger China children, there was no main effect of source (p = .985; SI Table 19), but there was an interaction between source and information type (p = .013), indicating that the greater tendency to repeat following rewarded ITs relative to unrewarded ITs was more pronounced in the Individual condition. In the older China children, there was no main effect of source (p = .652; SI 20), nor any interactions involving source ($p \geq .319$).

3.4 Discussion

The results from Experiment 1 were broadly replicated in Experiment 2, suggesting that our findings are not culturally specific. In particular, the children recruited in China, like those recruited in the UK, responded to information acquired socially and information acquired individually in broadly similar ways. In addition, across both populations and common to all age groups (see Figure 2), children were more successful following unrewarded ITs, compared with rewarded ones, i.e. they made far fewer lose-stay errors, compared with win-shift errors. We further investigate this apparent bias in performance in Experiment 3. Direct comparisons between the populations further confirmed that the patterns of performance were highly similar, including children's overall task success, suggesting that the demands of the task itself were not culturally specific (see Vu et al., 2017, for an example of the difficulty of establishing tasks suitable for cross-cultural comparison, even with adult participants).

The four-way interaction effect between population, source, information type, and age (on the repeats measure), and the corresponding three-way interaction between population, source, and age (success measure), suggested that there may have been population differences in age-related changes in response to the different task conditions. This could potentially be interpreted as nascent cultural differences in the use of information acquired socially versus individually, consistent with previous cross-cultural studies of social information use (in that the age effect was more pronounced in the Individual condition in the UK population, but not in the China population, e.g. Mesoudi et al., 2015). However, although these interactions were in the direction of the UK and China samples differing in directions consistent with previous literature to a greater extent in older, compared with younger, children, these effects appeared to be driven as much by trends in the *opposite* direction in the younger children (see results of unplanned analyses in Sections 3.3.1 and 3.3.2). It is therefore not possible to conclude that there are any differences of note between our two recruitment samples in relation to their use of social versus individual information for this task. Nonetheless, we believe that our results highlight the need for further research clarifying the ontogenetic trajectory of culturally-specific biases towards information acquired socially versus individually.

3.5 Model: Biased domain-general learning

In Experiments 1–2, task success increased with task experience (see Sections 2.3.1 and 3.3.1). To investigate this relationship further, we used a mathematical model of domain-general learning to analyse older children's TT selection sequences. This allowed us to perform a more sensitive evaluation of within-task learning effects, by taking into account participants' biases and personal feedback history. Identifying potential biases in participants' response strategies is particularly challenging in the current context, because the sequential nature of the task inherently motivates a degree of exploration (Kaelbling et al., 1996) that is difficult to quantify. A solution to this analytical dilemma is to quantify the explore-exploit trade-off specific to every individual's feedback sequence. The statistically optimal response to this trade-off can be cast as a form of Bayesian learning. Modelling within-task learning as Bayesian inference (Perfors et al., 2011) allows us to calculate a trial-by-trial benchmark against which children's errors can be compared. See SI 3.2 for model details and analysis.

We first characterised the predicted increase in task success over trials under the assumption that participants were responding to feedback in an unbiased way, i.e. not subject to any a priori preference for repeating or deviating from IT selections. Figure 3 (top row) shows that this model fails to predict the initial asymmetry in task success between rewarded and unrewarded ITs, and over-predicts task success following rewarded IT selections. We then performed a maximum likelihood analysis to estimate the model's bias parameter from children's patterns of errors. The biased model dramatically outperforms the unbiased alternative, providing a close correspondence with children's task success profiles (Figure 3, bottom row). Figure 4 shows the biases we inferred. The log-likelihood surface of the experimental data characterises the probability of children's decisions under each possible setting of the model's biases (Lewandowsky and Farrell, 2011). In this case, it suggests that to account for children's selection profiles, the model must include an a priori bias against repeating IT selections. Crucially, the likelihood surfaces for these biases are highly overlapping when calculated independently from trials involving a Social or Individual source. In other words, accounting for each participant's personal feedback history, and inferring a data-driven estimate of the children's biases, our analysis is suggestive of: (1) a robust preference against repeating IT selections, that is (2) strongest in the context of unrewarded ITs, and therefore (3) consistent with an expectation for win-stay, lose-shift reward structures, and (4) is independent of source.

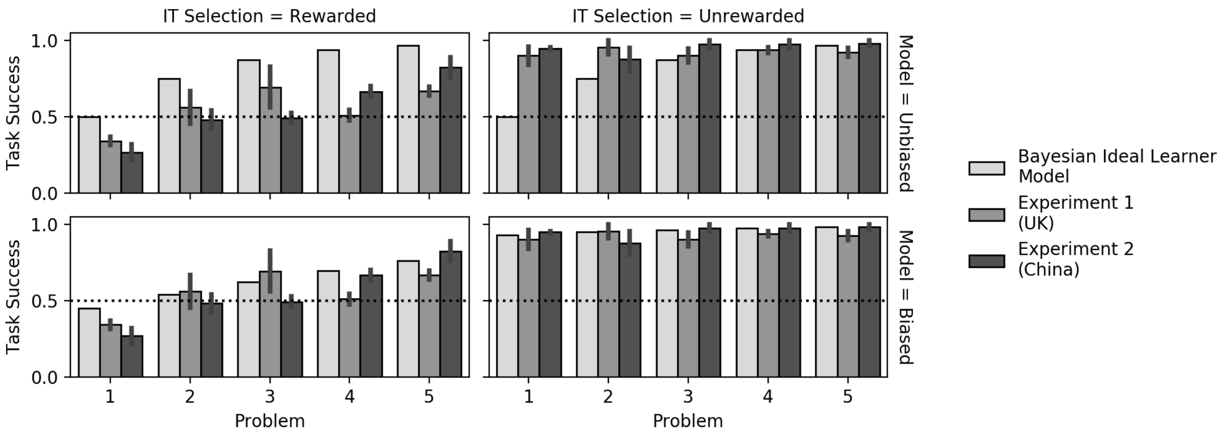

Figure 3: **Task success accounting for within-task feedback & learning.** Task success across problem sequences in Experiments 1–2 alongside expected task success under a model of unbiased (top row) and biased (bottom row) within-task learning. The model captures the performance profile of a domain-general statistical learner using feedback to induce the underlying reward structure over problems. Children's task success profiles are better captured by the biased model that includes an inherent preference against repeating IT selections. Task success in both experiments is consistent with the predictions of domain-general learning under an a priori preference that is gradually overturned by feedback following rewarded IT selections (left) and reinforced by feedback following unrewarded IT selections (right).

4 Experiment 3: Children's error patterns in a task with a reverse predictive relationship between information and test trials

Although not part of our original predictions, Experiments 1–2 identified robust error types, across both populations and within all age groups. Children made more errors following rewarded ITs compared with unrewarded ones, and did so whether they had acquired the information socially or individually.

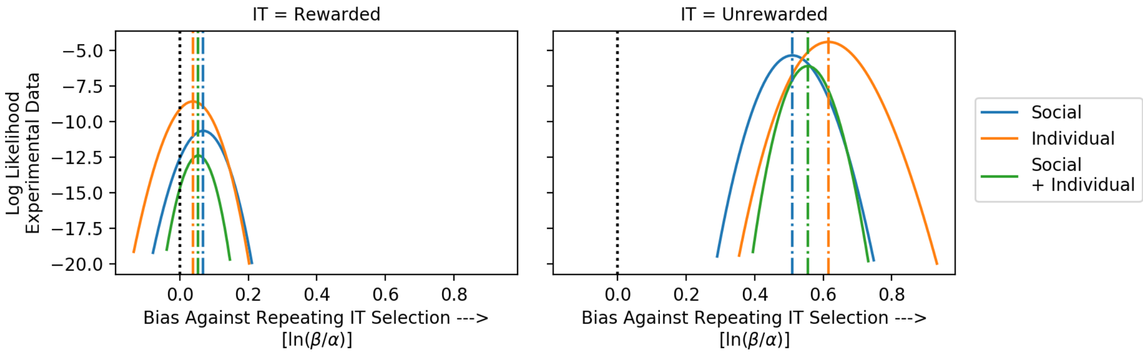

Figure 4: **Estimated biases against repeating IT selections.** The combined log likelihood of children's TT selections (Experiments 1–2, Stage A, children age 4 years and above) under a model of domain-general learning that accounts for each child's individual feedback history, as a function of the model's bias parameters. Dashed lines show the maximum-likelihood estimate of the model's bias. Dotted black lines at zero denote the unbiased parametrisation. Solid lines show likelihood surfaces for TT selections following Social information (blue), Individual information (orange), and both combined (green). In both rewarded (left) and unrewarded (right) problems, independent of whether the IT included social or individual information, the likelihood of the experimental data is robustly maximised by a bias against repeating IT selections. The model's initial, task-naive preference to repeat IT selections is given by α, and its willingness to deviate from IT selections is given by (β). The ratio β/α quantifies a preference to deviate from IT selections. The logarithm of this ratio is larger than zero if β is larger than α. See SI 3.2 for details.

They did this in spite of the fact that, broadly speaking, they appeared to correctly infer the predictive value of the IT, even in the absence of task experience, since task success was above chance from the first problem. Children therefore seemed to have implicitly assumed that the reward value of a stimulus revealed during the IT would hold true for the subsequent trial of the same problem. This was further corroborated by children's performance on a task which rewarded all TT responses, which we carried out as a means of testing children's expectations about the predictive value of the IT in the absence of any differential feedback (Experiment 4; SI 5). The error pattern could be accounted for in two main ways. Children might have had greater difficulty using or remembering information obtained from rewarded ITs compared with unrewarded ones, limiting expression of their knowledge of the task structure. Alternatively, children might have accurately encoded the content of the IT, but have greater motivation to perform shift responses compared with stay responses, even at the expense of task success. This could occur if, for example, children were motivated to maximise their knowledge of all potential reward locations, even if this meant selecting a novel stimulus at the expense of forgoing a reward.

The current experiment was designed to tease apart these alternatives by using a task with a reversed reward structure (i.e. using a win-shift, lose-stay contingency) so that the reward's location was in different positions in the IT and TT. Of the two possibilities outlined above, we regarded the second as more plausible, i.e. the relatively high occurrence of win-shift errors was due to the children exploring the space over exploiting the information obtained. Furthermore, we had no particular reason to believe that experiencing a rewarded IT would make the task inherently more difficult than an unrewarded one. We therefore predicted that for the current reversed reward structure task, shifting errors (this time lose-shift) would continue to be more prevalent than staying errors (this time win-stay). We preregistered these predictions accordingly (`https://osf.io/qtpnm`).

As a secondary goal, this experiment allowed us to further investigate how children learned to use information acquired socially versus individually. In Experiments 1–2, our task clearly met children's expectations about the predictive relationship between the IT and TT. Therefore, there was a limit to the extent to which we could determine how participants learned to use the information, given that they performed above chance from the first problem (see Figure 2, top panels). The current experiment therefore offered an opportunity to investigate how effectively children could learn the underlying predictive IT/TT relationship using the different sources, given that in this case the relationship deviated from their default expectations.

We collected data from 184 children aged 5 and under, in Glasgow, UK. We kept the experimental procedures as close as possible to Experiments 1–2, aside from the nature of the predictive relationship between the IT and TT. Therefore even though only Stage A was appropriate for analysis here, we included a Stage B with the reversed reward structure so as to use the same instructions as for Experiments 1–2, and give children and parents/guardians the same expectations of experiment length. We did not analyse the Stage B data. Note that in Stage B, and unlike in Stage A and both stages in Experiments 1–2, the child's TT selection would influence the position of the reward; not only would it be difficult to make any meaningful predictions about how they would behave, but the information in the different conditions could not be considered equivalent.

4.1 Methods

The design was the same as for Experiments 1–2, except that the reward was located in a different position between the ITs and TTs for a particular problem. Therefore in Stage A, if a chosen stimulus revealed the monkey on the IT, the child could find the monkey on the TT only by choosing the alternative stimulus. If a chosen stimulus revealed no monkey on the IT, the child could find the monkey only by re-selecting this stimulus.

A Stage B was included to keep the experimental procedures as close as possible to Experiments 1–2. We only analysed the Stage A problems.

4.2 Participants

We collected data from 184 children aged 5 and under in Glasgow, UK (see SI 4 for details). The ethical approaches of this study were reviewed and granted approval by the General University Ethics Panel of the University of Stirling.

4.3 Results

In contrast to Experiments 1–2, most of the 184 children completed all 10 Stage A problems without achieving five consecutive successful TTs (154 children: 84%; see SI 2.4.1 for more details). We therefore analysed all of the Stage A data here.

4.3.1 Task success

Task success was *below* chance (M = 0.46, SD = 0.21, $p = .002$; SI Table 21). In the Individual condition, average task success was 0.65 (SD = 0.38) following rewarded ITs and 0.31 (SD = 0.35) following unrewarded ITs. In the Social condition, average task success was 0.62 (SD = 0.35) following rewarded ITs and 0.27 (SD = 0.30) following unrewarded ITs.

There was no effect of source ($p = .279$), nor any significant interactions involving source ($p \geq .107$). Unlike in Experiments 1–2, and reflecting the reversed reward structure, task success was greater following *rewarded* ITs ($p < .001$), and this was more pronounced in older children (information type x age: $p < .001$). Success overall increased with age ($p = .030$). There was no effect of problem number ($p = .075$).

See SI 2.5 for analysis of task success (and proportion of repeats) for the combined Experiments 1–3 data with reward structure as an additional variable.

4.3.2 Repeats

Although our predictions concerned only the success measure, we also report analyses of the repeats variable to determine whether children were responding differently to rewarded and unrewarded ITs. Children's overall rates of repetition were below chance (M = 0.33, SD = 0.28, $p < .001$; SI Table 22). There was a main effect of information type, due to significantly lower proportions of repeats following unrewarded (M = 0.29, SD = 0.33) compared with rewarded ITs (M = 0.37, SD = 0.37, $p < .001$). This was particularly evident in older children (information type x age: $p < .001$).

Children therefore did respond differently depending on the IT type, although for this task this was in the opposite direction to that reinforced by the reward structure (see Figure 2), consistent with their success being significantly below chance. As with Experiments 1–2, older children repeated less than younger ($p < .001$), and there was no evidence of an effect of source ($p = .907$).

4.4 Discussion

The results were broadly in line with our predictions. As in Experiments 1–2, children tended to repeat previously rewarded responses more than previously unrewarded responses. For this task, this occurred in spite of the opposite pattern being rewarded. Children thus had lower success rates for this task than in the previous experiments. We interpret this as reflecting the fact that the win-stay, lose-shift structure fits better with their prior intuitions about the likely predictive relationship between ITs and TTs (i.e. that reward location would not change).

We also found a sustained overall preference for deviating from a previously selected stimulus in this task, as expected. Here, this had the effect of generating lower success following unrewarded ITs, compared with rewarded, whereas in the previous experiments children had achieved greater success following unrewarded trials. We interpret this pattern as being due to a motivation to explore a novel location (consistent with, e.g., Valenti, 1985), regardless of the source of the IT.

The response patterns identified in the current experiment once again appeared to be robustly replicated across both information source conditions, providing no indication social information was treated differently from information acquired from personal experience.

5 General discussion

Our results provided no evidence to suggest that young children responded to information acquired from social observation in fundamentally different ways to information acquired from personal experience. Our methodological paradigm made it possible to compare responses to information from these two sources in a manner that ensured that the information obtained could be understood to be truly comparable. In our task, the information acquired was purely episodic (i.e. tied to that specific context). Also, if a demonstrator's behaviour did not lead directly to a reward, this provided a straightforwardly contra-indicative signal, and it did so in exactly the same way that feedback from one's own personal exploration should, independent of any assumptions about relative experience or knowledge of either actor.

We did however identify strong biases in how children approached the task, which were common across our information source conditions. Firstly, we found that children consistently displayed a bias to explore a novel location, rather than repeat the selection made in the IT (consistent with previous literature looking at either individual learning only, Levinson and Reese, 1967; Berman et al., 1970; Berman, 1971; or social learning only, Valenti, 1985). In the tasks with a win-stay, lose-shift reward structure (Experiments 1–2) this generated poorer performance following rewarded ITs compared with unrewarded. In the win-shift, lose-stay task (Experiment 3) this generated the opposite pattern in relation to success.

It is important to note however that the suboptimal performance identified in Experiments 1–2 was precisely that (i.e. below ceiling, but nonetheless above chance, including following rewarded ITs). We attribute this to the second robust performance bias, once again common across all datasets, ages, and experimental groups. This was the children's prior expectation of a win-stay, lose-shift structure; their performance suggested that they assumed that the location of the reward remained fixed. This meant that children tended to repeat previously rewarded responses, and avoid previously unrewarded ones. Clearly this reflected a prior bias rather than an effect of the reinforcement contingencies built into the task, since it was true even for task-naive participants in Experiments 1–2, and furthermore was true for participants in Experiment 3, despite the fact that the reverse pattern (win-shift, lose-stay) was rewarded (see also Experiment 4; SI 5).

In relation to our overarching point regarding the similarities of responses to socially and individually acquired information, it is important to emphasise that both of these striking patterns of behaviour (i.e. the exploration bias and the expectation of congruent reward location) were manifested in virtually identical ways regardless of source. We did find some interaction effects involving information source in Experiments 1–2. However, post-hoc analyses on subsets of the samples failed to identify any group exhibiting differences in performance following socially versus individually acquired information. We also found some indication of possible differences between the cultural populations in the precise effects of source (see the four-way interaction involving source and population for the repeats measure in Section 3.3.2). In the older children, this was in a direction consistent with the literature on cultural differences in adult populations in relation to use of information acquired socially vs. individually (Mesoudi et al., 2015). We emphasise that our cross-cultural data collection was not designed to investigate the ontogenetic roots of population-specific patterns and so do not draw strong conclusions about the (relatively subtle) differences between populations observed in our datasets. However, we suggest that further investigation is warranted based on these findings, and there is potential for future research to identify key age ranges at which cultural differences in relative reliance on social information begin to appear. On a similar note, future work could also aim to establish the age at, and contexts under, which social information may be typically prioritised less than equivalent individual information (as suggested by the results of, e.g., McElreath et al., 2005; Efferson et al., 2007; Eriksson and Strimling, 2009; Novaes Tump et al., 2018).

Overall, our results offer no support for the view that humans possess (relatively) experience-independent learning mechanisms which are specific to social information use (contra, e.g., Meltzoff, 1988, 1999; Tomasello, 1999; Herrmann et al., 2007; McGuigan et al., 2007; Hill et al., 2009; Tennie et al., 2009; Whiten, 2011; Dean et al., 2014; Henrich, 2016; Tennie et al., 2016). We see no evidence for overall performance differences dependent on information source, and so no evidence that young children are particularly attentive to social information. We also see remarkably similar rates of repetition following rewarded information in both conditions, and similar rates of repetition following unrewarded information in both conditions, within each experiment. There is therefore no evidence here that children repeat others' behaviour, whether reinforced or not, any more than they repeat their own, and there is no evidence that either social or individual learning is more "high-fidelity" than the other. This pattern of results is more consistent with the view that mechanisms that appear specialised for cultural learning in humans are likely to be relatively experience-dependent, rather than present from birth (see Heyes, 2012b, for further discussion). With respect to the cultural transmission of complex technology in particular, our results are also consistent with Osiurak and Reynaud (2019), who suggest that it is "technical reasoning", rather than social learning mechanisms, which underpin the acquisition of technological cumulative cultural traits. If their theory is correct, then information use would involve source-independent learning processes, and so we would not (necessarily) expect social information and equivalent individually-acquired information to elicit different responses.

As noted in the Introduction, social information may be prioritised in certain contexts, such as where it is quantifiably more useful or less risky to obtain, and this may be particularly the case for certain traits where naive personal experience may be of limited value, or where the methods of use or function (e.g. of a tool) is less immediately transparent. Social information may also be the only means of acquiring some traits, such as cultural norms and rituals. But our results suggest that any prioritisation of social information use, or the human ability to acquire particular cultural traits, is not due to some (relatively) experience-independent learning processes which are specific to social information use. Similarly, we do not discount humans having, relative to other primate species, strong, relatively experience-independent, tendencies to attend to social stimuli (see Heyes, 2018, 2019, for discussion). It is possible that humans may have distinctive "input mechanisms" that make social information available for learning (even if there is no evidence to support this account in the results we present here), but it does not necessarily follow that they also have learning mechanisms which are specific to social information use (Heyes, 2012a,b).

We cannot, of course, rule out there being relatively experience-independent learning mechanisms which are specific to social learning use, but that we have failed to capture them in our experiments here. It is possible some specifics of our task design led to apparently source-independent patterns of behaviour which would not generalise to other tasks. We would welcome follow up work which involved, for example, different presentation media, different numbers of stimuli, or different reward structures, along with extensions of this work which consider older or younger participants. It is also conceivable, for example, that the patterns of behaviour observed here would not generalise to alternative social learning scenarios, and the future work could involve more complex behaviours so the child in a social condition would be exposed to, for example, longer observations of another individual, or social demonstrations which they interact with in some way. We would also be keen to see this work extended to a less abstract context if, crucially, it were possible for the experimental methodology to overcome the limitations of previous work identified above. Given the hypothesis that technological trait acquisition is underpinned by "technical-reasoning skills" (Osiurak and Reynaud, 2019), rather than learning mechanisms specific to social information use, it would be particularly interesting if such a methodology could assess the use of information for a more tool-like trait. An alternative possibility is that the social context of the task common to both our conditions — the child taking part in the presence of the experimenter using a tablet computer — influenced information use in both cases in similar ways, masking more subtle source-independent differences in information use. We think this unlikely due to the fundamental differences in the conditions discussed in the Introduction: if there were social-learning-specific responses employed by the children in our samples, we do not believe we would have observed such strikingly similar patterns of behaviour between our conditions. Nevertheless, we would of course welcome further investigation of the effect of information source in other paradigms where the value of the information in both conditions was still comparable.

Finally, we cannot altogether rule out the possibility that it is the comparable use of (otherwise equivalent) social and individually-acquired information that is specific to human behaviour. Other species, such as chimpanzees, may make greater use of the individual information even if equivalent social and individually-acquired information were available (Tennie et al., 2009; Renner et al., in press). Humans may be the anomaly in being able, perhaps through relatively experience-independent social learning processes, to make comparable use of social and individual information. The results we present here cannot discount this possibility, and future work is necessary to determine whether other species do indeed make better use of individually-acquired information than social information when the information can be considered truly equivalent. Ongoing work by our research group is aiming to establish whether or not this is the case in nonhuman primates, using a similar methodology to the one we present here (Renner et al., 2019; Kean et al., in prep.; Renner et al., in prep.).

In conclusion, we believe that our main finding, i.e. the apparent source independence of the patterns of performance, provides good grounds to urge caution in the interpretation of studies of social learning. In particular we encourage restraint in proposing adaptive mechanisms which are relatively independent of experience, and which assume that effects identified are necessarily specific to social information use, particularly in the absence of evidence that socially and individually acquired information is treated differently when that information is truly equivalent. Apparent peculiarities of social information use may in fact represent developmental effects of more general biases in learning, which would also apply equally to contexts not involving social information use if tested under appropriately matched conditions. They may not reflect specialised biological adaptations for the acquisition of the contents of cumulative culture.

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