

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

23 experience. Children’s use of the information thus appeared independent of source. Fur-
24 thermore, children’s suboptimal performance showed evidence of a consistent bias driven
25 by motivation for exploration as well as exploitation, which was apparent across both con-
26 ditions and in both samples. Our results are consistent with the view that apparent pecu-
27 liarities identified in human social information use could be developmental outcomes of
28 general-purpose learning and motivational biases, as opposed to mechanisms that have
29 been biologically selected specifically for the acquisition of cultural information.

30 **Keywords**— social learning; cumulative cultural evolution; learning mechanisms; human behaviour;
31 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

65 is even present in blind babies; Freedman, 1964; Valente et al., 2018) and social tolerance develop
66 with little or no input (see Heyes, 2018, 2019, for review and discussion). Toward the other end of the
67 continuum, special treatment of social information could be relatively experience-*dependent*, as, for
68 example, literacy is (Heyes and Frith, 2014). However, many theorists suggest, or assume, that there are
69 social-learning-specific processes for learning from others, functioning to promote rapid enculturation,
70 which are present from birth (Tomasello, 1999; Tennie et al., 2009; Dean et al., 2014; Henrich, 2016;
71 Tennie et al., 2016), i.e. that are, at least relatively, *independent* of a person's experience.

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

85 This raises the question of whether young children do respond to social inputs in fundamentally
86 different ways, relative to information obtained through their own direct personal experience, and if
87 they do, at what age this specialisation develops. To test this, it is crucial to compare treatment of social
88 and individual information when the value of the information obtained is equivalent, i.e. when the only
89 difference in the information is its source. Human social learning has been characterised as a "high
90 fidelity" transmission process, in this respect distinct from lower resolution social influence observed
91 in other species (e.g. Tennie et al., 2009). It has also been proposed that high-fidelity copying may
92 represent a functional adaptation, selected for the ability to accelerate the transmission of potentially
93 beneficial, but causally opaque, cultural traits (e.g. Herrmann et al., 2007; Lyons et al., 2007; Whiten
94 et al., 2009). Yet do children repeat socially learned behaviours with more "high fidelity" than they
95 repeat those they learn through personal exploration? There is also the question of whether children

96 are particularly attentive to social information, and able to learn from it as proficiently (or possibly
97 even more so) as they do from their own experience. These are fundamental predictions which remain
98 untested in the literature, yet examining young children's treatment of equivalent social and individual
99 information has the potential to shed light on the extent to which the apparent peculiarities of human
100 social information use are relatively experience independent or experience dependent.

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

119 Furthermore, although children will bring different expectations to any experimental task regarding
120 the value of information from a social source compared with their own exploration (and past experi-
121 ence means they are likely to, regardless of the task in question), in these standard methodological
122 paradigms it is not possible to systematically study the extent to which new experiences update weight-
123 ings assigned to these expectations. Since what is learned is generalisable knowledge, updating from
124 the carry-over of experiences themselves (i.e. effective and ineffective responses) cannot easily be sep-
125 arated from updating of the strategy (i.e. when to copy or persist with responses observed or attempted
126 previously, and when to deviate from these). Indeed, within methodological paradigms which involve

127 learning how to operate physical apparatuses, there is generally no way of specifying a categorical and
128 finite set of possible responses that might be performed, since these are continuous, and the problem
129 space itself is ill-defined. This makes it difficult to equate the information value available from observing
130 or experiencing a response that generates a desirable outcome, from one that appears not to do so. An
131 action seen to produce a desirable outcome might well be expected to be repeated, and at a higher rate
132 than would be expected given no such experience. However, it does not follow that an action with a
133 more ambiguous outcome should be avoided, or indeed how to quantify the possible alternatives and
134 their respective baseline probabilities.

135 In this study we therefore use an abstract stimulus choice task, for which information acquired per-
136 sonally or socially was only episodic, that is, specific to a particular problem (i.e. particular set of stimuli),
137 with the critical test trial occurring directly after the initial information trial. The reward structure is ex-
138 plicit, with the reward arbitrarily assigned to one of the response options. The predictive relationship
139 between the information trial and test trial is also consistent. Therefore, assuming participants have
140 understood or been able to learn this task structure, in a binary choice the information trial (whether
141 rewarded or unrewarded) provides unambiguous information about the location of the reward. The
142 task also allows us to directly manipulate the baseline probability of making a particular response over
143 the possible alternatives simply by varying the number of stimuli, and therefore the potential responses.
144 This allows us to investigate the generalisability of response patterns, in determining whether a particu-
145 lar response pattern is carried over from one version of the task (such as the binary choice task in Stage
146 A of Experiments 1–2 described below) to another (such as the three-stimulus choice task in Stage B
147 of Experiments 1–2). Finally, since the stimuli are arbitrary, and the reward location is randomly as-
148 signed, multiple problems can be presented to the same participant, as any carry-over effects linked to
149 the structure of the stimuli themselves (e.g. same side, or similar shape or colour as another previously
150 associated – or not – with a reward) should have no systematic influence on the child’s likelihood of
151 selecting one of the responses over another. Thus we can study the effect of repeated experience of
152 multiple problems on learning the optimal response strategy (i.e. win-stay, lose-shift for Experiments
153 1–2, although c.f. Experiment 3).

154 Discrimination learning tasks such as the one we use here have been widely used in comparative
155 as well as developmental psychology, and have provided evidence of the formation of learning sets in
156 children and nonhuman primates (e.g. Harlow, 1949; Levinson and Reese, 1967). Studies of preschool
157 children have thus far focused on learning from personal experience only (information trial and test trial

158 both completed by the participant), but these indicate that children can successfully apply a win-stay,
159 lose-shift rule, and show improved performance with increasing task experience. In the experiments
160 reported here, we directly compare the test trial performance of children who made their own infor-
161 mation trial selections with the performance of those who observed information trials performed by
162 the experimenter. Thus we exploit the fact that the information trial always provides definitive, but
163 problem-specific, information about reward location, as a means to compare the efficacy of use of so-
164 cial and individual information when these have directly (and transparently) equivalent predictive value.

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

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

200 2 Experiment 1: Children's use of socially and individually ac- 201 quired information (UK)

202 2.1 Methods

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

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

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

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

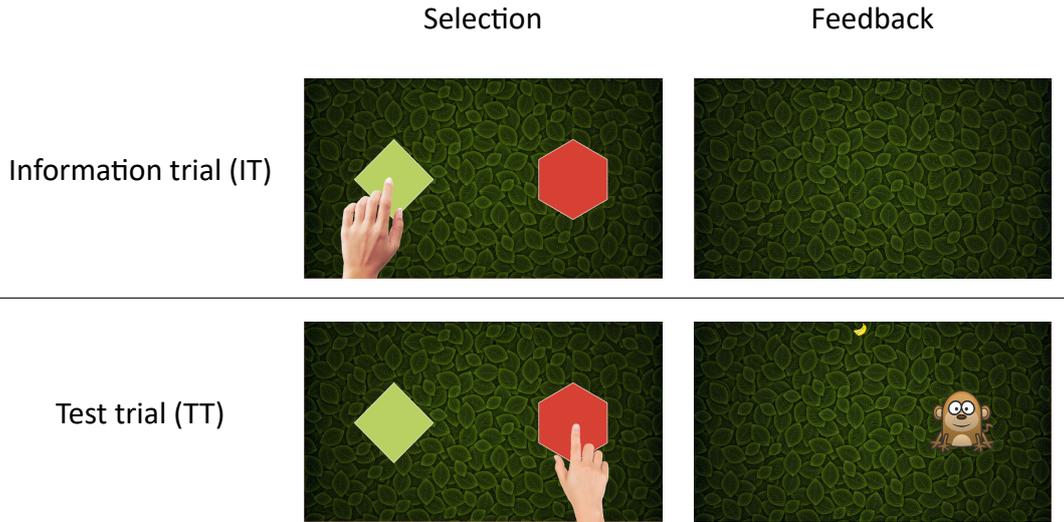


Figure 1: **Example Stage A problem.** In the IT, the child is shown two stimuli and one of these is selected, by either the child (Individual condition) or the experimenter (Social condition; illustrated above with the top hand being the researcher’s and the bottom being the child’s). Here, the left 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.

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

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

231 In the **Social condition**, the procedure was the same, except the experimenter, rather than the par-

232 ticipant, made the selection in the IT. The stimulus selected in each case was determined by a randomly
233 generated list. As with the Individual condition, of the 10 possible problems, five were rewarded and
234 five unrewarded, in a randomised order.

235 See SI 4 for additional methodological details.

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

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

249 2.2 Participants

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

254 2.3 Results

255 The analyses we report throughout are planned analyses, unless explicitly stated otherwise. Both suc-
256 cess and repeats measures were binary coded: a successful TT was 1, and 0 otherwise; a TT repeat was
257 1, and 0 otherwise.

258 In the first analysis, we investigated how task success varied with problem number, and the in-
259 teraction between problem number and source, and also how task success was influenced by source,

260 information type, age, and their interactions. Of the 172 children, 41 (24%) located the reward in each
261 of the first five problems of Stage A, and so completed no further Stage A problems (see SI 2.1.1 for more
262 details). For between-subject comparison purposes therefore, our analysis of task success considered
263 only the first five problems of Stage A, which are illustrated in Figure 2 alongside proportion repeats and
264 the results of Experiments 2-3. Analysis of success in Stage B is in SI 2.1.2, and an illustration of repeats
265 for all the Stage A and B data is in SI 1.

266 All analyses involved generalised linear mixed effects models with logit link using R (R Core Team,
267 2013) and *lme4* (Bates et al., 2013), taking p-values < .05 as statistically significant. Where significant
268 interaction terms involving source and age were indicated, we investigated the effect of source on the
269 younger (under 4 years old) and older (4 and over) children post hoc, by repeating our analysis on the
270 two subsets of the data separately. Model details for all analyses of Experiments 1–3 are given in SI 2.

271 2.3.1 Task success

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

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

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

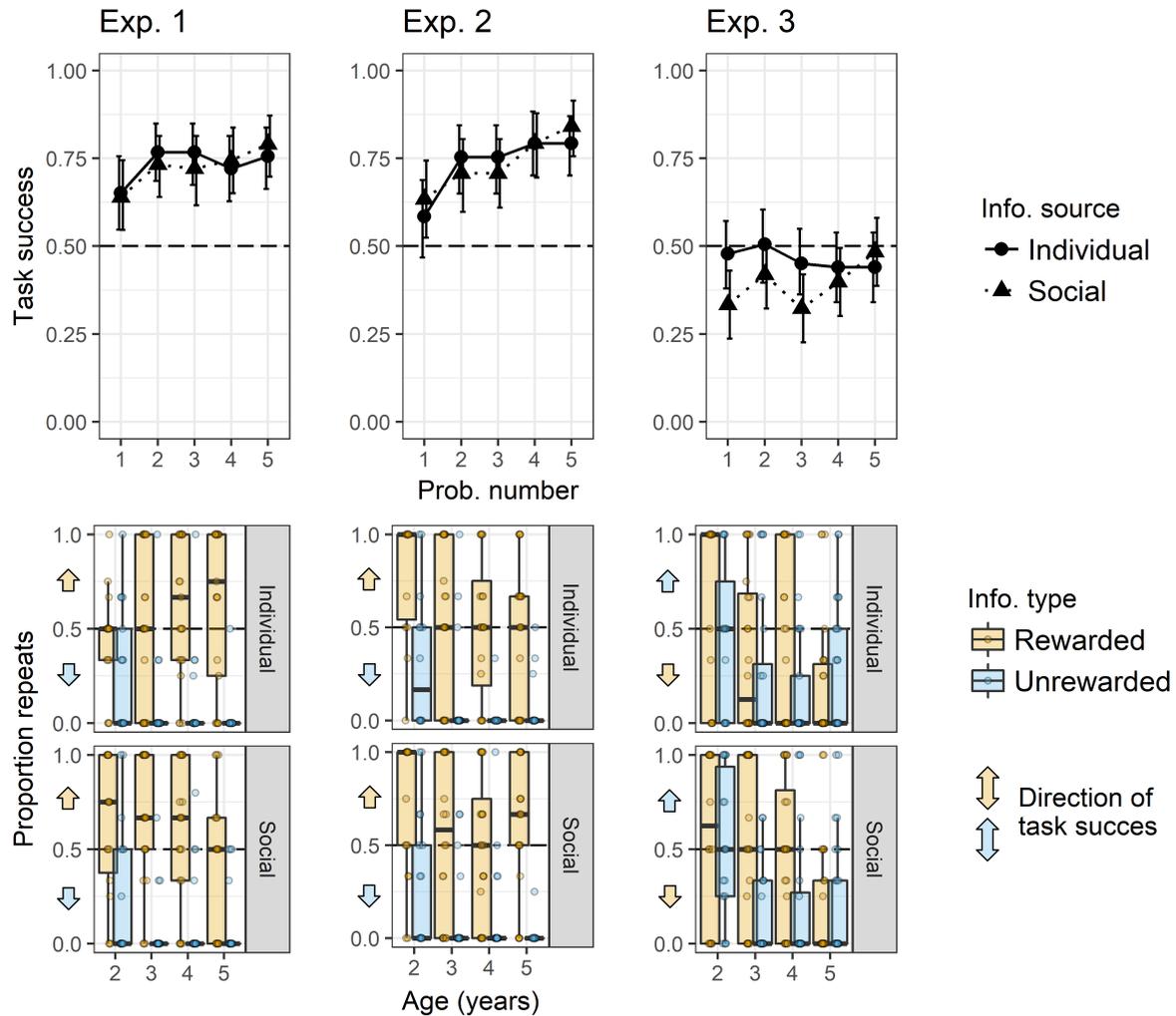


Figure 2: Task success by source and problem number (top row) and proportion of repeats by age (whole years) and information type (bottom row) for Problems 1–5 of Stage A for Experiments 1–3. Task success error bars are 95% confidence intervals. Proportion repeats arrows indicate whether repeats or non-repeats 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.

287 2.3.2 Repeats

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

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

295 There was no evidence of an overall effect of source ($p = .454$; SI Table 5). Children's overall rates of
296 repetition were not significantly different between Stage A ($M = 0.35$, $SD = 0.21$) and Stage B ($M = 0.36$,
297 $SD = 0.18$, $p = .739$). This is in spite of the chance-level probability of repeating an IT selection in the TT
298 being different between Stages A and B (50% vs. 33%). There were more repeats following rewarded
299 ITs (Stage A: $M = 0.62$, $SD = 0.33$; Stage B: $M = 0.65$, $SD = 0.33$) compared to unrewarded ITs (Stage A:
300 $M = 0.09$, $SD = 0.19$; Stage B: $M = 0.07$, $SD = 0.17$, $p < .001$).

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

313 2.4 Discussion

314 We found no evidence of any difference in overall success rates between the Social and Individual con-
315 ditions. And although success rates were higher for later problems, there was also no evidence that

316 this strategy-learning effect was any stronger for one condition over another. Overall, children’s TT per-
317 formance was above chance, regardless of the source and type of information to which they were ex-
318 posed. They tended to repeat rewarded responses, and deviate from those that had been unrewarded,
319 regardless of whether the information was acquired socially or individually. Children were more likely to
320 deviate from unrewarded responses than they were to repeat rewarded ones. This was true across the
321 full age range, and in both the Social and Individual conditions. We return to this bias and test a possi-
322 ble explanation for its prevalence in Experiment 3. Performance on three-way discrimination problems
323 (presented after the two-way discrimination problems) was also well above chance, and the tendency
324 to repeat rewarded selections, and avoid unrewarded selections, did not appear to be influenced in line
325 with the change in corresponding chance levels (33% vs. 50% for chance-level repetition). Although this
326 suggested that information was being used in a relatively “high fidelity” manner, this effect was again
327 common to both the Social and Individual conditions. Overall therefore we found little evidence of chil-
328 dren responding differently to information acquired from a social source compared with that acquired
329 individually. The patterns of performance we observed (which included remarkably consistent patterns
330 of below-ceiling performance in apparently task-competent individuals) did not appear to reflect a spe-
331 cific social learning strategy, but more general learning and motivational biases (see Section 5). Finally,
332 children’s overall success rates increased with age, and there were also weak interaction effects: the
333 age effect was more pronounced in the Individual condition, suggesting that relative performance in
334 response to individual and social information might change with age. We return to this point below in
335 Section 3.

336 3 Experiment 2: Children’s use of socially and individually ac- 337 quired information (China)

338 Experiment 1’s results may reflect a real, generalisable, equivalence in how children respond to infor-
339 mation acquired socially and individually, once potential confounding factors are stripped away (see
340 above). However, an absence of noteworthy differences in a specific sample provides only weak sup-
341 port for the conclusion that social and individual information are treated in similar ways, particularly if
342 we hope to draw more general conclusions about children’s learning that extend beyond this sample.
343 In a study carried out across seven different societies, for example, cross-cultural variation was found
344 in children’s rates of repetition of demonstrated actions, versus an alternative, non-demonstrated, re-

345 sponse (van Leeuwen et al., 2018). This study considered only socially acquired information, however,
346 so it is not clear whether these cultural differences reflected variation in dependence on social informa-
347 tion specifically, or preferences for novelty or exploration not restricted to social learning contexts. Pre-
348 vious work has also suggested that societies characterised by the prevalence of particular attitudes and
349 cognitive styles may show associated patterns in the relative reliance placed on information acquired
350 from social versus individual sources (Mesoudi et al., 2015; Glowacki and Molleman, 2017; Triandis,
351 1995; Triandis and Gelfand, 1998; Gelfand et al., 2011). Past literature has focused in particular on
352 distinctions in individualism/independence versus collectivism/interdependence (e.g. Triandis, 1995),
353 but other dimensions have also been found to differentiate societies in significant ways that might be
354 expected to impact on the importance placed on information acquired socially (e.g. horizontal/verti-
355 cal, Triandis and Gelfand, 1998; and tight/loose, Gelfand et al., 2011). We therefore attempted to repli-
356 cate our results from Experiment 1 using a sample of participants from China, a population of particular
357 interest for a number of reasons. Firstly, it was important to extend the research beyond populations
358 typically sampled in human behavioural research (as stressed by Henrich et al., 2010; Nielsen et al.,
359 2017). Secondly, adults from China had already been reported to make greater use of social information,
360 relative to participants from the UK, in an experimental task (Mesoudi et al., 2015). Finally, Chinese so-
361 ciety is generally described as being more “collectivist”/“interdependent” than the UK (Triandis, 1995),
362 as well as scoring higher for “tightness” in relation to the importance placed on social norms (Gelfand
363 et al., 2011).

364 3.1 Methods

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

368 3.2 Participants

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

372 3.3 Results

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

375 3.3.1 Task success

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

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

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

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

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

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

399 3.3.2 Repeats

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

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

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

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

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

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

421 Though not evident in the separate analyses of the Experiments 1–2 datasets, there were fewer
422 repeats in Stage B relative to Stage A ($p = .032$), especially following unrewarded ITs (information type
423 x stage $p < .001$); this was particularly the case in the older children (information type x stage x age:
424 $p = .019$). Relative to the UK population, the greater number of repeats following rewarded ITs com-
425 pared to unrewarded ITs was more pronounced in the China population (information type x population:
426 $p = .008$).

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

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

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

443 3.4 Discussion

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

454 The four-way interaction effect between population, source, information type, and age (on the re-
455 peats measure), and the corresponding three-way interaction between population, source, and age
456 (success measure), suggested that there may have been population differences in age-related changes
457 in response to the different task conditions. This could potentially be interpreted as nascent cultural dif-
458 ferences in the use of information acquired socially versus individually, consistent with previous cross-
459 cultural studies of social information use (in that the age effect was more pronounced in the Individual

460 condition in the UK population, but not in the China population, e.g. Mesoudi et al., 2015). However,
461 although these interactions were in the direction of the UK and China samples differing in directions
462 consistent with previous literature to a greater extent in older, compared with younger, children, these
463 effects appeared to be driven as much by trends in the *opposite* direction in the younger children (see
464 results of unplanned analyses in Sections 3.3.1 and 3.3.2). It is therefore not possible to conclude that
465 there are any differences of note between our two recruitment samples in relation to their use of social
466 versus individual information for this task. Nonetheless, we believe that our results highlight the need
467 for further research clarifying the ontogenetic trajectory of culturally-specific biases towards informa-
468 tion acquired socially versus individually.

469 3.5 Model: Biased domain-general learning

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

481 We first characterised the predicted increase in task success over trials under the assumption that
482 participants were responding to feedback in an unbiased way, i.e. not subject to any a priori preference
483 for repeating or deviating from IT selections. Figure 3 (top row) shows that this model fails to predict
484 the initial asymmetry in task success between rewarded and unrewarded ITs, and over-predicts task suc-
485 cess following rewarded IT selections. We then performed a maximum likelihood analysis to estimate
486 the model’s bias parameter from children’s patterns of errors. The biased model dramatically outper-
487 forms the unbiased alternative, providing a close correspondence with children’s task success profiles
488 (Figure 3, bottom row). Figure 4 shows the biases we inferred. The log-likelihood surface of the ex-
489 perimental data characterises the probability of children’s decisions under each possible setting of the

490 model’s biases (Lewandowsky and Farrell, 2011). In this case, it suggests that to account for children’s
 491 selection profiles, the model must include an a priori bias against repeating IT selections. Crucially, the
 492 likelihood surfaces for these biases are highly overlapping when calculated independently from trials
 493 involving a Social or Individual source. In other words, accounting for each participant’s personal feed-
 494 back history, and inferring a data-driven estimate of the children’s biases, our analysis is suggestive of:
 495 (1) a robust preference against repeating IT selections, that is (2) strongest in the context of unrewarded
 496 ITs, and therefore (3) consistent with an expectation for win-stay, lose-shift reward structures, and (4)
 497 is independent of source.

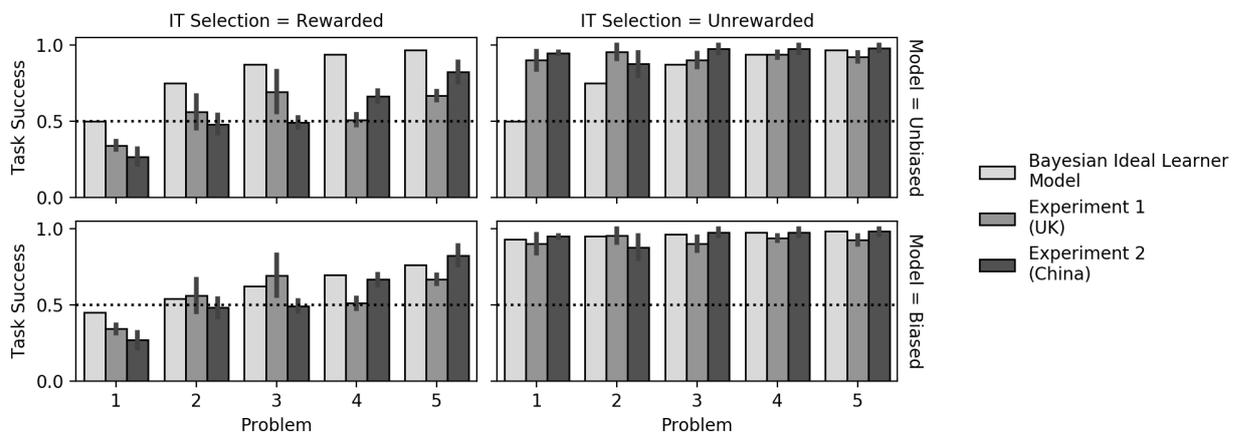


Figure 3: **Task success accounting for within-task feedback & learning.** Task success across problem sequences in Experiments 1–2 alongside expected task success under a model of unbiased (top row) and biased (bottom row) within-task learning. The model captures the performance profile of a domain-general 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).

498 4 Experiment 3: Children’s error patterns in a task with a reverse 499 predictive relationship between information and test trials

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

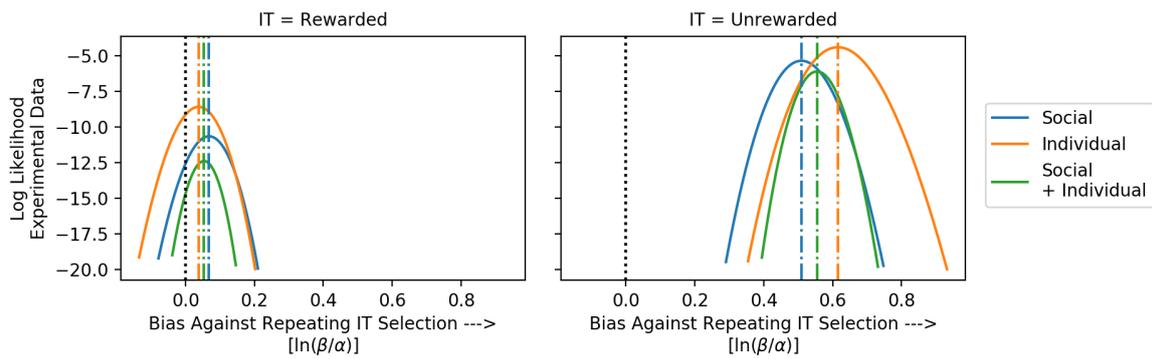


Figure 4: **Estimated biases against repeating IT selections.** The combined log likelihood of children’s TT selections (Experiments 1–2, Stage A, children age 4 years and above) under a model of domain-general learning that accounts for each child’s individual feedback history, as a function of the 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.

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

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

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

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

543 4.1 Methods

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

549 A Stage B was included to keep the experimental procedures as close as possible to Experiments
550 1–2. We only analysed the Stage A problems.

551 4.2 Participants

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

555 4.3 Results

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

559 4.3.1 Task success

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

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

569 See SI 2.5 for analysis of task success (and proportion of repeats) for the combined Experiments
570 1–3 data with reward structure as an additional variable.

571 4.3.2 Repeats

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

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

582 4.4 Discussion

583 The results were broadly in line with our predictions. As in Experiments 1–2, children tended to repeat
584 previously rewarded responses more than previously unrewarded responses. For this task, this occurred
585 in spite of the opposite pattern being rewarded. Children thus had lower success rates for this task
586 than in the previous experiments. We interpret this as reflecting the fact that the win-stay, lose-shift

587 structure fits better with their prior intuitions about the likely predictive relationship between ITs and
588 TTs (i.e. that reward location would not change).

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

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

597 5 General discussion

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

607 We did however identify strong biases in how children approached the task, which were common
608 across our information source conditions. Firstly, we found that children consistently displayed a bias to
609 explore a novel location, rather than repeat the selection made in the IT (consistent with previous liter-
610 ature looking at either individual learning only, Levinson and Reese, 1967; Berman et al., 1970; Berman,
611 1971; or social learning only, Valenti, 1985). In the tasks with a win-stay, lose-shift reward structure (Ex-
612 periments 1–2) this generated poorer performance following rewarded ITs compared with unrewarded.
613 In the win-shift, lose-stay task (Experiment 3) this generated the opposite pattern in relation to success.

614 It is important to note however that the suboptimal performance identified in Experiments 1–2 was
615 precisely that (i.e. below ceiling, but nonetheless above chance, including following rewarded ITs). We

616 attribute this to the second robust performance bias, once again common across all datasets, ages, and
617 experimental groups. This was the children’s prior expectation of a win-stay, lose-shift structure; their
618 performance suggested that they assumed that the location of the reward remained fixed. This meant
619 that children tended to repeat previously rewarded responses, and avoid previously unrewarded ones.
620 Clearly this reflected a prior bias rather than an effect of the reinforcement contingencies built into
621 the task, since it was true even for task-naive participants in Experiments 1–2, and furthermore was
622 true for participants in Experiment 3, despite the fact that the reverse pattern (win-shift, lose-stay) was
623 rewarded (see also Experiment 4; SI 5).

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

643 Overall, our results offer no support for the view that humans possess (relatively) experience-
644 independent learning mechanisms which are specific to social information use (contra, e.g., Meltzoff,
645 1988, 1999; Tomasello, 1999; Herrmann et al., 2007; McGuigan et al., 2007; Hill et al., 2009; Tennie
646 et al., 2009; Whiten, 2011; Dean et al., 2014; Henrich, 2016; Tennie et al., 2016). We see no evidence

647 for overall performance differences dependent on information source, and so no evidence that young
648 children are particularly attentive to social information. We also see remarkably similar rates of repeti-
649 tion following rewarded information in both conditions, and similar rates of repetition following unre-
650 rewarded information in both conditions, within each experiment. There is therefore no evidence here
651 that children repeat others' behaviour, whether reinforced or not, any more than they repeat their own,
652 and there is no evidence that either social or individual learning is more "high-fidelity" than the other.
653 This pattern of results is more consistent with the view that mechanisms that appear specialised for
654 cultural learning in humans are likely to be relatively experience-dependent, rather than present from
655 birth (see Heyes, 2012b, for further discussion). With respect to the cultural transmission of complex
656 technology in particular, our results are also consistent with Osieurak and Reynaud (2019), who suggest
657 that it is "technical reasoning", rather than social learning mechanisms, which underpin the acquisition
658 of technological cumulative cultural traits. If their theory is correct, then information use would involve
659 source-independent learning processes, and so we would not (necessarily) expect social information
660 and equivalent individually-acquired information to elicit different responses.

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

674 We cannot, of course, rule out there being relatively experience-independent learning mechanisms
675 which are specific to social learning use, but that we have failed to capture them in our experiments
676 here. It is possible some specifics of our task design led to apparently source-independent patterns
677 of behaviour which would not generalise to other tasks. We would welcome follow up work which

678 involved, for example, different presentation media, different numbers of stimuli, or different reward
679 structures, along with extensions of this work which consider older or younger participants. It is also
680 conceivable, for example, that the patterns of behaviour observed here would not generalise to alter-
681 native social learning scenarios, and the future work could involve more complex behaviours so the
682 child in a social condition would be exposed to, for example, longer observations of another individ-
683 ual, or social demonstrations which they interact with in some way. We would also be keen to see this
684 work extended to a less abstract context if, crucially, it were possible for the experimental methodology
685 to overcome the limitations of previous work identified above. Given the hypothesis that technologi-
686 cal trait acquisition is underpinned by “technical-reasoning skills” (Osiurak and Reynaud, 2019), rather
687 than learning mechanisms specific to social information use, it would be particularly interesting if such
688 a methodology could assess the use of information for a more tool-like trait. An alternative possibility
689 is that the social context of the task common to both our conditions — the child taking part in the pres-
690 ence of the experimenter using a tablet computer — influenced information use in both cases in similar
691 ways, masking more subtle source-independent differences in information use. We think this unlikely
692 due to the fundamental differences in the conditions discussed in the Introduction: if there were social-
693 learning-specific responses employed by the children in our samples, we do not believe we would have
694 observed such strikingly similar patterns of behaviour between our conditions. Nevertheless, we would
695 of course welcome further investigation of the effect of information source in other paradigms where
696 the value of the information in both conditions was still comparable.

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

708 In conclusion, we believe that our main finding, i.e. the apparent source independence of the pat-

709 terns of performance, provides good grounds to urge caution in the interpretation of studies of social
710 learning. In particular we encourage restraint in proposing adaptive mechanisms which are relatively
711 independent of experience, and which assume that effects identified are necessarily specific to social
712 information use, particularly in the absence of evidence that socially and individually acquired infor-
713 mation is treated differently when that information is truly equivalent. Apparent peculiarities of social
714 information use may in fact represent developmental effects of more general biases in learning, which
715 would also apply equally to contexts not involving social information use if tested under appropriately
716 matched conditions. They may not reflect specialised biological adaptations for the acquisition of the
717 contents of cumulative culture.

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