Who do children copy? Model-based biases in social learning

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Abstract

This review investigates the presence of young children's model-based cultural transmission biases in social learning, arguing that such biases are adaptive and flexible. Section 1 offers five propositions regarding the presence and direction of model-based transmission biases in young children's copying of a model. Section 2 discusses the cognitive abilities required for differing model-based biases and tracks their development in early childhood. Section 3 suggests future areas of research including considering the social aspect of model-based biases and understanding their use within a comparative perspective.

1   Social learning is ubiquitous in humans, and fundamental to children's development,

2   but alone cannot explain the unique stability and diversity of human culture. Research from a

3   plethora of academic discplines investigating cultural evolution has escalated in recent years

4   (Boyd, Richerson, & Henrich, 2011; Whiten, Hinde, Laland, & Stringer, 2011), increasing

5   our understanding of the circumstances that facilitate social learning. Theoretical models of

6   cultural evolution predict the evolution of flexible strategies enabling avoidance of unreliable

7   or redundant information, and influencing the circumstances under which individuals copy

8   others (Boyd & Richerson, 1985). Thus, social learning is not seen as inherently beneficial

9   and must be used selectively in the context of the observer's environmental and model-based

10   cues (characteristics of a demonstrator exhibiting a behaviour pattern). The use of such cues

11   in guiding behaviour is known as 'cultural transmission biases' (Boyd & Richerson, 1985,

12   also termed 'social learning strategies'; Laland, 2004) and allows populations to approach

13   adaptive optima much faster than they otherwise would under individual learning (Mesoudi

14   & O'Brien, 2008) or unbiased social learning in which individuals acquire variants according

15   to the frequency at which they are practiced (Rendell et al., 2011).

16   The adaptive value of model-based biases have been investigated in disciplines such

17   as evolutionary biology, anthropology and non-developmental domains of psychology.

18   Model-based biases have been described as 'who' biases (Laland, 2004), indirect biases

19   (Boyd & Richerson, 1985) and context dependent model-based biases (Henrich & McElreath,

20   2003). Within developmental psychology it has long been established that it is important to

21   understand whom children learn from, and that children's learning entails 'an active construct

22   of the model by the individual' (Užgiris, 1981, p. 2). As children develop they constantly

23   witness alternative methods of achieving a goal. This has been mirrored in experiments where

24   children witness divergent information from different models relating to tool-use (Wood,

25   Kendal, & Flynn, in prep), and labels for elements in the environment (Koenig, Clément, &

26   Harris, 2004). When faced with divergent information it would be adaptive to select and

27   reproduce the information that achieves the outcome most suited for one's needs, but this can

28   be complex. Models have different characteristics that influence our choice, including their

29   previous performance, knowledge state, age, sex and social status. Furthermore, observers'

30   own characteristics may influence who is the 'best' model for them. The potential list of

31   relevant characteristics is endless and a naïve individual needs to evaluate these

32   characterisitcs so that the behaviour of the most appropriate model, potentially providing the

33   most useful and adaptive behaviour, is adopted.

34   This review uses an evolutionary approach to understand how model characterisitcs

35   bias the likelihood that an observing child copies modelled behaviour. We define copying as

36   a broad behaviour of a child either matching the behaviour of a model or preferentially

37   selecting one model's behaviour (e.g. a novel object is given a different word label by two

38   models and when prompted, the child repeats one of the models' word labels). Copying is an

39   important mechansim in children's social learning. Whilst focusing on instances of copying a

40   model, we acknowledge that children are able to learn behaviour without necessarily

41   reproducing every aspect of a demonstration (Bekkering, Wohlschläger, & Gattis, 2000;

42   Flynn & Whiten, 2008; Williamson, Meltzoff, & Markman, 2008) and that copying a model

43   may serve a function beyond simply learning behaviour (Over & Carpenter, 2011). In Section

44   1 we argue that model-based biases enable children to gain the most useful information

45   pertaining to their environment; hence a model-based bias may be viewed as an adaptive

46   cognitive tool. Throughout this review, adaptive means that the model-based bias contributes

47   to an individual's survival by providing them with more useful behaviours within their

48   environment, or enables avoidance of unreliable or redundant information, than if such a

49   model-based bias did not exist. In Section 2 we describe the developmental shift in the

implementation of model-based biases, demonstrating increasingly flexible implementation.

We conclude in Section 3 by discussing future considerations and directions.

Section 1: The adaptive value of model-based biases

In this section we make five propositions regarding the adaptive value of model-based biases. To begin, we examine children's biases towards models whose behaviour indicates their desire to transfer information, namely children's receptiveness to pedagogical cueing. Second, we consider children's ability to evaluate and copy the most proficient individual before moving on to discussing characteristics that identify models as belonging to groups with certain reputations that may guide children's copying. Fourth, we argue that the more similar a model is to a child, the more suitable s/he might be as a model, before finishing by discussing children's biases towards models that are prestigious.

Proposition 1: Children are biased towards those who intend to teach

Csibra and Gergely (2009) argue that children have an innate predisposition for receptiveness towards people's ostensive signals indicating that the person is trying to communicate relevant information. These cues may include pointing, eye contact, and verbal directions. If a person is actively trying to communicate information then, generally, the person is communicating information about the environment that they believe will assist the observer. Being sensitive to a model's ostensive cues is adaptive because it enables children's attention to be drawn to important aspects of the environment. The sensitivity to ostensive cues is present from infancy, for example fourteen-month-olds search where they see someone point (Behne, Carpenter, & Tomasello, 2005) and copy the unusual action of turning a light on with their head if told by the model "I'm going to blick the light' as opposed to just "Look at this" (Chen & Waxman, 2013). This sensitivity influences which

75   models individuals copy; children copy a model more when s/he stoops to the child's level,

76   leans in, makes eye contact and talks engagingly (Brugger, Lariviere, Mumme, & Bushnell,

77   2007), gives verbal cues about the importance of actions (Southgate, Chevallier, & Csibra,

78   2009) or performs actions in a seemingly purposeful, rather than accidental manner

79   (Carpenter, Akhta, & Tomasello, 1998; Gardiner, Greif, & Bjorklund, 2011). Indeed this

80   receptiveness to pedagogical cueing is so strong it can limit exploratory play and discovery

81   (Bonawitz, Shafto, Gweon, Goodman, Spelke, & Schulz, 2011). Thus, children are receptive

82   to pedagogical cueing and are biased towards copying models who attempt to share

83   information about the environment.

84

85   **Proposition 2: Children are biased toward copying the most proficient models**

86   A model's success in a particular context indicates his or her ability to deal with that

87   environment, therefore a successful model's behaviour is the most adaptive behaviour to

88   adopt. There is evidence that infants are able to discriminate between models who act

89   competently or incompetently (Zmyj, Buttelmann, Carpenter, & Daum, 2010) and seven-

90   year-old children preferentially copy children rated by an experimenter as being competent

91   rather than less competent (Brody & Stoneman, 1985). Likewise, the 'Trust' paradigm

92   (Harris, 2007; Koenig & Harris, 2005a), whereby children are introduced to one reliable

93   model (e.g., labels a ball, "ball") and one unreliable model (e.g., labels a ball, "shoe"), has

94   demonstrated that, from infancy to six-years-old, children consistently copy reliable models

95   over unreliable labellers for novel words (Koenig et al., 2004; Koenig & Harris, 2005b;

96   Vázquez, Delisle, & Saylor, 2012) and artefact use (Birch, Vauthier, & Bloom, 2008; Zmyj et

97   al., 2010). The labelling of artefacts are more likely to be copied from models who self-

98   declare they know what is right (declaring, "this is a spoon") than models who are uncertain

99   ("*I think* this is a fork"; Jaswal & Malone, 2007) and models who are labelled as smart rather

100   than not smart (Lane, Wellman & Gelman, 2012). Thus, children are able to discern the

101   proficient model and are biased towards the information this model provides.

102

103   **Proposition 3: Children are biased toward copying models belonging to a group which**

104   **has a reputation for being proficient**

105   Employing model-based biases regarding an individual's proficiency is costly in

106   terms of time and cognitive processing, as it requires an assessment of the behavioural history

107   of a model. Instead, it is more efficient for an individual to be biased towards characteristics

108   of models that are easily identifiable, often indicating an individual's membership to a group.

109   This group may have a different reputation for proficiency from another group leading to

110   model-based biases. For example, a salient characteristic indicating group membership is age.

111   A 'copy older over younger models' strategy seems adaptive because older individuals have

112   had more experience with the environment and, by their continued existence, have made

113   successful choices within the environment. Such age biases exist. Fifteen-month-olds are

114   more likely to copy videotaped target acts when presented by an adult versus a two-year-old

115   child (Seehagen & Herbert, 2011). Younger (one- to two-year-olds) siblings copy the

116   spontaneous social behaviours of their older (three- to five-year-old) siblings far more than

117   the other way around regardless of age gap or sex differences (Abramovitch, Corter, &

118   Pepler, 1980; Pepler, Abramovitch, & Corter, 1981). Three- and four-year-olds preferentially

119   copy information provided by an adult over a child for novel object labelling (Jaswal &

120   Neely, 2006), and object less when a puppet copies an adult, rather than a child model

121   demonstrating alternative actions on a novel game (Rakoczy, Hamann, Warneken, &

122   Tomasello, 2010). Also, seven- and eight-year-olds copy the food choices of older rather than

123   younger children (Brody & Stoneman, 1981). This bias towards copying older individuals is

124   also seen in the reproduction of causally irrelevant actions by children; when models use

125 causally-inefficient tools, adults are more likely to be copied than children (Elekes & Kiraly,

126 2012), two- and three-year olds do not copy the irrelevant actions demonstrated by a peer to

127 the same extent as when demonstrated by adult models (Flynn, 2008; Horner & Whiten,

128 2005), and three- and five-year-olds copy relevant actions of both child and adult models but

129 only faithfully reproduce the irrelevant actions of adults (McGuigan, Makinson, & Whiten,

130 2011; Wood, Kendal, & Flynn, 2012). Potentially, children assume that increased age

131 indicates increased proficiency and use this bias to guide their copying (although see Section

132 2 for instances where this does not happen).

133

134 **Proposition 4: Children are biased toward copying models that resemble themselves**

135   Individual differences result in individualised needs within an environment. These

136 differences can influence children's proclivity to gain information from a model that is most

137 similar to them, an 'observer-specific model-based bias'. This observer-specific bias may

138 happen at a genetic, physiological or cultural level. For example, four- and five-year-olds

139 generally accepted their mother's claims over those of a stranger (Corriveau et al., 2009)

140 indicating that children may select information from those more genetically related to them.

141 Familiarity is a confound to this interpretation, yet familiarity itself can be a marker of in-

142 group membership and infants copy more actions of a familiar, compared to an unfamiliar,

143 model (Learmonth, Lamberth, & Rovee-Collier, 2005). Likewise, three- to five-year-old

144 children, given conflicting artefact labels and functions from a known or unknown teacher,

145 preferentially copy the known teacher (Corriveau & Harris, 2009b). Children also copy the

146 choices of familiar models when choosing personal preferences or labelling artefacts (Shutts,

147 Kinzler, McKee, & Spelke, 2009) and in tool use tasks (Buttelmann, Zmyj, Daum &

148 Carpenter, 2012; Seehagen & Herbert, 2011). This preference for copying familiar models is

149 adaptive because the child and the model have definite overlaps in their environment whereas

150   the history of the stranger is unknown and, therefore, the information they provide may not

151   be relevant for the child's particular environment.

152   Another salient physiological group difference is sex and whilst sex is not necessarily

153   correlated to ability within our environment, children may be influenced by cultural sex-role

154   norms. Indeed, eighteen-month-old children discriminate between stereotypical male and

155   female artefacts (Serbin, Poulin-Dubois, Colburne, Sen, & Eichstedt, 2001). Likewise, three-

156   year-olds copy the preferences of same-sex (over different-sex) child models for personal

157   preferences of novel food, clothes, toys and games (Frazier, Gelman, Kaciroti, Russell, &

158   Lumeng, 2011; Shutts, Banaji, & Spelke, 2010) and copy the novel word label from a same

159   sex rather than opposite sex adult model when both adults were equally reliable (Taylor,

160   2013). This adoption of sex-specific behaviour may provide children with relevant

161   information pertaining to their physiological needs or it may enable them to learn behaviours

162   expected of their sex by their cultural group.

163   Learning other appropriate behaviour for one's cultural group seems fundamental to a

164   child's development and there is evidence for a bias towards copying those belonging to the

165   same cultural group. Twelve-month-olds show a personal preference for foods endorsed by a

166   speaker of their native language versus a model speaking a foreign language (Shutts et al.,

167   2009). Likewise, five- and six-month-old infants attend more to a model speaking natural

168   English over a model speaking 'reverse' English (the audio was played backwards) or a

169   foreign language, and infants are also biased towards selecting a toy endorsed by a model

170   speaking their native language (Kinzler, Corriveau, & Harris 2011) or using a native accent

171   (Kinzler, Dupoux, & Spelke, 2007). Language is one of the most basic markers of cultural

172   identity and, as seen with familiarity, a bias towards copying models who share your culture

173   may be adaptive because the cultural similarity indicates a shared environment, and,

174   therefore, the behaviour of the most similar model may be the most relevant.

175

Proposition 5: Children are biased towards copying models with high status

Status incorporates two forms of social power; *dominance*, defined as an ability to

acquire and monopolise resources over others, often through threatened or actual antagonism,

and *prestige,* defined as status through non-agonistic means achieved through excelling in

valued domains. Henrich and Gil-White (2001) note the importance of differentiating these

two forms of status, which have their 'own distinct psychology, selected for by distinct

evolutionary pressures' (p. 166). Humans can exhibit status through non-agonistic means and

attainment of high prestige may reflect an individual's superior ability to deal with his/her

physical or social environment. The behaviour of high-status individuals, whether the status

was acquired through skill or force, may thus be adaptive. In turn, it would be adaptive to

copy models of high status, although such an adaption may result in copying behavioural

traits that do not relate to the attainment of higher status (Mesoudi & O'Brien, 2008), hence

the term 'indirect bias' (Boyd & Richerson,1985).

Teacher ratings of social status and dominance of children correlate with observable

characteristics, such as the age of a child (Grusec & Lytton, 1988), his/her size, and the

number of wins in agonistic encounters with other children over resources (Pellegrini et al.,

2007). Flynn and Whiten (2012) investigated both dominance and prestige in pre-school

children's social learning. There was evidence of a status-based model-based observation bias

in these children; in a naturalistic, open diffusion setting with a novel puzzle-box, older

children were watched more than younger children, popular children were watched more than

less popular children, and more dominant children were watched more than less dominant

children. This observation bias indicates a potential copying bias of more prestigious

individuals. As dominant children did not monopolise the task, it seems they were watched

out of choice. Further, children were more likely to watch task manipulations made by peers

200   they stated that they 'liked' rather than peers they stated that they did 'not like'. Likewise,

201   McGuigan (2013) found that the higher the status of the model (the child's head teacher

202   versus a known researcher) the greater the number of irrelevant actions were copied.

203   Whether a model is observed by others may, in itself, be a marker of prestige; four-

204   year-old children use bystanders' silent reactions to models such that a model who was

205   'endorsed' by bystanders through nods and smiles was copied more for labelling novel

206   artefacts than a model whose behaviour was met with negative bystander reactions (Fusaro &

207   Harris, 2008). This endorsement effect occurs even when the bystander attendance is neutral

208   in comparison to an ignored model (Chudek, Heller, Birch, & Henrich, 2012). Children are

209   receptive to the status of others and are biased towards copying those who have higher status

210   both in terms of dominance and prestige. It would be fruitful to explore the nature of the

211   relation between model status and often associated characteristics, such as proficiency and

212   age, to discover what factors contribute towards prestige. Likewise, to investigate whether

213   biased copying from prestigious models is, in some circumstances, limited to behaviour

214   which potentially contributes to the attainment of prestige, rather than being indiscriminate in

215   this regard as theoretically assumed (Boyd & Richerson, 1985).

216

217   **Summary**

218   We have outlined five propositions relating to the presence and adaptive value of

219   model-based biases. Indeed, the propositions outlined can be adapted to make testable

220   predictions about model-based biases. For example, in line with Proposition 1 we predict that

221   any model who, through verbal or non verbal means, communicates an intention to teach will

222   be more likely to be copied than a model who provides no cues or non-pedagogical

223   communication. Likewise, we predict that, in line with Proposition 3, groups that have a

224   reputation for being more proficient will be copied more than comparative groups. Whilst this

225   section focussed on age we believe that other groups relating to, for example, profession,

226   level of education or expertise, could illicit the same model-based biases.

227   The evidence presented demonstrates that children monitor the characteristics or

228   behaviour of others and use this to guide their own behaviour. Such abilities drive children to

229   copy others, hence socially learn, in a discriminating manner. This behaviour goes beyond

230   simply copying, as it is *biased* copying and it is this bias which makes copying adaptive. The

231   skills required for the implementation of biases are varied. Some model characteristics, such

232   as a model's age and sex, are salient whilst others, such as proficiency and professed

233   knowledge state, are more subtle. Evaluation of these more subtle cues requires the

234   development of certain cognitive skills, such as an ability to track behaviour and understand

235   the knowledge states of others. The next section presents some of the cognitive skills that

236   improve the application of model-based biases and discusses their development in line with

237   the findings from the social learning literature.

238

239   **Section 2: The development of cognitive skills enabling model-based biases**

240   This section reflects on some cognitive skills required in two periods of child development,

241   infancy and early childhood, which enable and assist in implementing model-based biases.

242   The cognitive skills described here are relatively high-level and based on empirical papers

243   detailing model-based biases. Therefore, lower-level cognitive processes, such as working

244   memory, categorisation or language development are not discussed, although future work

245   addressing the influence of these processes on model-based biases seems pertinent. Cognitive

246   skills develop throughout infancy and early childhood and this development affects the use of

247   model-based biases. We argue that these developing cognitive skills enable children to

248   flexibly employ model-based biases in response to environmental and behavioural cues. This

249   flexibility is important because it allows children to continually source and copy the 'best'

250   model even when there are complex, subtle and multiple model characteristics.

251

252   **From Infancy**

253   **Perspective taking.** From infancy children respond differently depending on a

254   model's visual access to stimuli and, therefore, potentially what the model knows (Koenig &

255   Echols, 2003; Liszkowski, Carpenter, & Tomasello, 2008). This perspective taking may

256   facilitate the earliest forms of a model-based bias of proficiency. For example, a model who

257   saw where a toy was hidden should be more proficient at locating the toy than a model who

258   was unable to see where it was hidden. Such a model is more proficient in the immediate

259   situation, as opposed to having a reputation for being proficient.

260   **Monitoring reactions to the model's behaviour.** Infants are also able to monitor the

261   reaction of others towards a model's behaviour. Infants avoid copying an action when

262   unknown adults react negatively to an adult model's actions (Repacholi, 2009) or show

263   irritation towards the model (Repacholi & Meltzoff, 2007). A similar pattern is found in

264   three- and four-year-olds when the model is a same-aged peer (Frazier et al., 2011) and also

265   with novel word copying in four-year-olds who copy the novel artefact labels of models for

266   whom bystanders react with smiles, more than the labels given by models for whom

267   bystanders react with frowns (Fusaro & Harris, 2008). This ability to take account of the

268   reactions of others could facilitate two model-based biases proposed in Section 1: first, the

269   reactions of others may indicate that the model has performed a behaviour that pleases or

270   displeases others and, therefore, indicates some degree of third-party evaluated model

271   proficiency (proposition 2), and second, the reactions of others may be directed towards the

272   model themselves and this could indicate some level of prestige (proposition 5). Presenting

273   third-party bystanders who disapproved of clearly correctly modelled behaviour will help

274 differentiate between these biases. Either way, the ability to monitor the reactions of others is

275 a useful skill in the implementation of model-based biases.

276   **Considering context.** The best model in one context may not be the best model in

277 another context, and children appear to show flexibility in the model-based biases employed.

278 Six-month-olds are more likely to copy an action demonstrated by their mother over a

279 stranger (the experimenter) in the infants' homes, but in a laboratory this pattern is reversed

280 and they preferentially copy the experimenter (Seehagen & Herbert, 2012). These authors

281 suggest that infants have expectations about the two models' usefulness as teachers; they

282 spend much time with their mothers who demonstrate pedagogical cues in the familiar

283 environment. Conversely, an infant might have experienced unfamiliar people mostly in

284 unfamiliar settings and, thus, have either formed the expectation that unfamiliar people are

285 knowledgeable in unfamiliar environments or display associative learning of unfamiliar

286 models in unfamiliar environments. Such appreciation of context is sophisticated and as these

287 infants were only six-months-old it seems that adapting model-based biases in different

288 contexts is either automatic or learnt in the first few months of life and this flexibility may

289 contribute to the biases adaptive value.

290   Context also affects biases toward copying models belonging to a particular group,

291 such as an age group. One- and two-year-olds generally imitate spontaneous behaviour

292 exhibited by adults more than peers, but the context affects this replication, such that

293 imitation of parents is more likely to consist of motor skills (e.g. tool use) whereas affective

294 behaviours are imitated from siblings and peers (Kuczynski, Zahn-Waxler, Radke-Yarrow,

295 1987). These two types of behaviour (motor skills and affective behaviours) represent

296 different functions, and therefore could elicit different model-based biases. This extends into

297 early childhood; four- to five-year-old children imitate adults more than children and same

298 age peers when an action is novel, but copy a peer over an older child and adult when the

299   action is not novel (Zmyj et al., 2011). In the first context, the function may be to learn a new

300   skill and, therefore, children should be biased towards copying the model who belongs to the

301   more proficient group whereas in the second context, the action is familiar and, therefore, the

302   predominant motivation may be to copy behaviour appropriate for a child, and thus children

303   copy another child. Indeed, when the context is play infants show higher fidelity copying of a

304   three-year-old child versus an adult (Ryalls, Gul, & Ryalls, 2000) and peers over older

305   children and adults (Zmyj, Aschersleben, Prinz, & Daum, 2012), and children also prefer

306   clothes, toys, games and foods endorsed by children over those endorsed by adults (Shutts et

307   al., 2010). Furthermore, in a diffusion chain paradigm, when an adult demonstrated

308   functionally irrelevant actions, in a functionally oriented way, the first child copied these

309   actions but subsequent children parsed out the action of the child model they had witnessed

310   (Flynn, 2008). Conversely, when an adult model demonstrated irrelevant actions in a playful

311   way the behaviour spread; the children copied the child models (Nielsen, Cucchiaro, &

312   Mohomedally, 2012). This implies children assess the context and copy individuals

313   belonging to groups who will be most proficient in that context, so will most aid their

314   interaction with that environment. Alternatively, and as discussed in Section 3, copying may

315   not always be driven by a desire to learn but instead a desire to share a social experience

316   (Užgiris, 1981), or become more integrated with a social group (Over & Carpenter, 2012).

317   Context also influences perceptions of the relative proficiency of one model (or

318   group) over another model (or group). When three- to five-year-olds, presented with stick

319   figure 'adult' or 'child' models, were asked who would provide more reliable answers to

320   questions, children selected the adult when the questions were within the adult domain, such

321   as the nutritional value of food, but when the subject area was toys children deferred to the

322   child model (VanderBorght & Jaswal, 2009). An ability to consider the domain of the

323   behaviour alongside the model characteristics is adaptive as it allows for contextual flexibility

324 in behaviour. Moreover, children demonstrate flexibility in their choice, such that when

325 children are informed that a toy is 'the adult's favourite toy' they defer to the adult, rather

326 than a child model, for subsequent information regarding that toy (VanderBorght & Jaswal,

327 2009). The additional flexibility of understanding that there may be exceptions to a domain

328 appropriate model-based bias is cognitively sophisticated and adaptively biases the child

329 towards the most proficient model in each specific instance.

330   Evaluating context is an important skill in ensuring that model-based biases towards

331 certain models and categories (e.g. adult versus child) may be used flexibly. The flexibility of

332 biases ensure that whilst children have biases towards copying individuals based on their

333 group membership they understand that these groups have different skills involving varying

334 degrees of functional and social relevance for the observing child. Therefore, this flexibility

335 increases the adaptive value of model-based biases.

336

337 **From Early Childhood**

338   **Evaluating a model's testimony.** Evaluating model testimony is important for

339 proposition 2 (children are biased toward copying the most proficient models). Here we see

340 an example of a cognitive skill that develops throughout early childhood, influencing the

341 discrimination of particular models. Studies involving model testimony have shown that

342 three-year-olds show mixed discrimination of proficient and less proficient models, with

343 evidence of copying the behaviour of the reliable model (Birch et al., 2008; Corriveau &

344 Harris, 2009a) but also a lack of discrimination of accurate over inaccurate informants

345 (Koenig & Harris, 2005b). However, by four to six years, children consistently copy reliable

346 models over unreliable labellers for copying labels for novel objects (Koenig et al., 2004;

347 Koenig & Harris, 2005b; Vázquez et al., 2012) and artefact use (Birch et al., 2008). Six-year-

348 olds also copy reliable labellers over tangential labellers, who are not inaccurate but fail to

349   answer the question, although four-year-olds fail to make such a distinction (Vázquez et al.,

350   2012). Furthermore, three-year-olds have difficulty discriminating between models when the

351   reliable informant is anything other than 100% accurate, whereas four-year-olds are able to

352   make distinctions between a model who was right 75% of the time versus a model who was

353   right 25% of the time (Pasquini, Corriveau, Koenig, & Harris, 2007). Recently, Lucas, Lewis,

354   Pala, Wong & Berridge (2013) have shown an association between specific cognitive skills

355   and evaluation of a model's testimony; children who demonstrated stronger false belief

356   understanding were more likely to copy the model with the more accurate prior testimony,

357   than children with poorer false belief understanding. Whether it is the development of false

358   beliefs per se or the ability to hold in mind multiple constructs at the same time, irrespective

359   of whether they refer to mental states or not, this study shows a clear developmental shift in

360   the use of model based biases. Furthermore, this study highlights the importance of

361   investigating which specific cognitive skills affect model-based biases.

362   **Understanding knowledge states.** Another way in which models can be evaluated is

363   through the use of the model's self-declared knowledge state. Models can express different

364   levels of confidence in their knowledge state by using terms such as 'know', 'think', 'guess'

365   and 'don't know' that present a scale of knowledge confidence. Here, we see increasingly

366   sophisticated understanding of the subtle differences in model self-declared knowledge states,

367   throughout early childhood. For example, children as young as three years are able to

368   distinguish between a model verbally indicating uncertainty ("I think this is a spoon") and

369   one indicating certainty ("This is a spoon") in a novel word copying paradigm (Jaswal &

370   Malone, 2007), but struggle with subtleties of 'know', 'think' and 'guess' (Moore, Bryant, &

371   Furrow, 1989). By four years, children are able to distinguish between 'know' versus 'think'

372   or 'guess' and this improves with age, but until eight years children have difficulty

373   distinguishing between 'think' and 'guess' (Moore et al., 1989). With increasing age comes

374   an expanding vocabulary reflected in an increasing ability to differentiate the subtle

375   differences between model's self-declared knowledge state.

376   Children also adapt to the context of the responses; if a model's hesitant response

377   could be caused by indecision rather than uncertainty, four-year-olds are more likely to

378   accept a model's artefact label (Sabbagh & Baldwin, 2001) so as children develop they

379   become more skilled at evaluating the subtle differences in a model's declared knowledge

380   state. This understanding aids both children's assessment of the potential proficiency of the

381   model. For example, self-declared knowledge can assist in ascertaining the proficiency of the

382   model. Model-based biases involving a model's self-declared knowledge state occur from as

383   young as three years of age, with increased word learning (Sabbagh & Baldwin, 2001;

384   Sabbagh, Wdowiak, & Ottaway, 2003) and irrelevant action reproduction (Wood et al., 2012)

385   following demonstrations from models with declared knowledge versus declared ignorance.

386   **Assessing specialists and generalists.** Evaluation of model testimony might depend

387   upon the speciality of the model's knowledge and the speciality of the to-be-learnt behaviour.

388   Humans have common shared knowledge; we all know the difference between cats and dogs.

389   But we also have specialist knowledge; doctors have expertise in anatomy while farmers have

390   expertise with crops. It follows that if a model fails to show proficiency in shared general

391   knowledge the perception of his/her proficiency should be more negatively affected than if

392   the same model fails to show proficiency in an area of specialist knowledge. Young children

393   are able to make this important distinction, as three- and four-year-olds do not copy a model

394   who specialised in labelling dog species over a neutral model for novel artefact labelling, but

395   a model who wrongly labelled dogs as cats was not chosen over a neutral model (Koenig &

396   Jaswal, 2011). This skill improves with development (Koenig & Jaswal, 2011); whilst four-

397   year-olds do not generalise beyond word knowledge having witnessed a reliable word

398   labeller, five-year-old children generalise that the reliable word labeller will also excel in

399 broader facts (Brosseau-Liard & Birch, 2010). This assessment of specialists and generalists

400 allows children to use more subtle group membership model-based biases rather than more

401 salient distinctions (e.g. age) whilst ensuring that they realise the potential limitations of this

402 group membership.

403   **Tracking prior personal experience and knowledge.** A further evaluative tool

404 available to children is to evaluate models in comparison with their own knowledge. When

405 given no previous chance to interact with a task, five-year-olds will generally copy the

406 irrelevant actions demonstrated, but when they have successful prior interaction with a task,

407 children will copy a new solution demonstrated by a model but parse out the causally

408 irrelevant actions demonstrated by the model (Wood, Kendal & Flynn, 2013). Likewise,

409 three-year-old observers only copy a model until this modelled information results in failure,

410 and four- and five-year-olds improve upon this by only copying models up to the point at

411 which the social information provided by the model conflicts with their personal information,

412 the latter they then favour (Clément, Koenig, & Harris, 2004; Ma & Ganea, 2010).

413   A child's reliance on her personal information is affected by the interplay between the

414 efficacy of her own behaviour and the efficacy of the model's actions, such that children with

415 a difficult prior experience are more likely to imitate an adult's precise means of achieving

416 something, compared to children with an easy prior experience (Williamson et al., 2008).

417 When the model's tool choice conflicts with the child's knowledge of the optimum tool for

418 task completion, children ignore a model's choice unless the model explicitly states that her

419 method is functionally appropriate or when the model's choice is only slightly less efficient

420 than the child's preference (DiYanni & Kelemen, 2008). A developing confidence in one's

421 personal knowledge within a task thus ensures effective evaluation of a model's behaviour.

422 However, over confidence in one's personal information causes the rejection of potentially

423 useful social information (Jaswal, McKercher, & VanderBorght, 2008); here, children were

424   asked to pick which model gave the right plural or past tense of a novel word. A previously

425   unreliable model's choice was endorsed over a previously reliable model because the

426   unreliable model followed the general grammatical pattern known to the child (add an 's' for

427   plurals and 'ed' for past tense) rather than an irregular change in word. However, what is

428   unclear is whether children accepted the less reliable model's information or whether they

429   just used personal information. Whilst this may lead to a reluctance to accept potentially

430   reliable social information, generally, evaluating the model, relative to ones personal

431   information, generally ensures the critical use of model-based biases.

432   **Calibrating multiple pieces of information or cues.** There are instances whereby

433   children need to evaluate multiple pieces of information about a model and this information

434   may pertain to different biases presented in Section 1. For example, a child may receive

435   information from a proficient child or an incapable adult (Wood et al., 2012). When this

436   occurs, children need to calibrate biases regarding age and proficiency. For example, children

437   favour older, over younger, children when making food choices, only until older models are

438   shown to be less competent than younger models in an unrelated domain (Brody &

439   Stoneman, 1985), and three- and four-year-olds will choose to label a novel object in

440   accordance with a child model, rejecting the adult's label, if the adult's previous behaviour

441   was unreliable (Jaswal & Neely, 2006). Thus, children calibrate a group-based bias of model

442   age against, the potentially more informative, proficiency bias and are more biased towards

443   proficiency. Likewise, when the visual access of a model is more important than a reputation

444   for proficiency five-year-old children will rely more heavily on a model's visual access than

445   prior accuracy when locating a hidden object (Brosseau-Liard & Birch, 2011).

446   Such calibration also occurs with regard to familiarity and proficiency model-based

447   biases. When three- to five-year-old children were given conflicting artefact labels and

448   functions from a known or unknown teacher they copied the known teacher when no further

449   information was provided (Corriveau & Harris, 2009b). However, when the unfamiliar

450   teacher was more accurate than the familiar teacher at labelling familiar objects, four- and

451   five-year-old children moderated their trust of the models, whilst three-year-olds showed

452   little change in behaviour. Thus, calibration is another cognitive skill that shows changes with

453   development. Perhaps three-year-old children have a bias towards familiar adults but have

454   not developed a proficiency model-based bias. Such an explanation is unlikely as from

455   infancy children seem able to judge proficiency (Zmyj et al., 2010; see proposition 2).

456   Alternatively, three-year-old children may be more influenced by the familiarity bias than a

457   proficiency bias, due to a lack of social interactions with unfamiliar individuals. Lastly, three-

458   year-old children may struggle with such calibration in comparison to older children, perhaps

459   due to a poorer working memory. Such a proposal could be tested by assessing the calibration

460   of older individuals when a cognitive load is put upon their working memory.

461   There are other instances where children fail to calibrate; when two models *grasp* at

462   opaque cups, three- to four-year-olds choose the cup grasped by the model who saw which

463   cup held the reward (they choose the 'seeing' model), but when both models *point* at the

464   different locations children did not favour the 'seeing' model, indicating that the pointing of

465   the 'unseeing' model was confusing (Palmquist, Burns, & Jaswal, 2012). For children of this

466   age, the model-based biases towards pedagogical cues (pointing) may be stronger than biases

467   towards models that are proficient due to their visual access, the latter of which is more

468   cognitively complex for the child's understanding. Likewise, five-year-old children's

469   imitation of a model is more influenced by the model's group membership (adult versus

470   child) than the model's knowledge state (model stating knowledge or ignorance about task

471   completion) even though children of this age are able to correctly identify knowledge state

472   (Wood et al., 2012). This indicates that a failure to correctly calibrate biases is not due to a

473   lack of ability to implement one of the biases but due to the lack of experience a child has had

474   with multiple biases or the cognitive load required within such calibration.

475   Alternatively, young children may understand that a model's self-declared knowledge

476   state is not always an accurate gauge of the reliability or utility of the behaviour they exhibit.

477   A sophisticated assessment of a model's credibility must involve calibration of self-declared

478   knowledge and behavioural accuracy of the model. Adults are able to make such calibrations

479   (Tenney, MacCoun, Spellman, & Hastie, 2007; Tenney, Spellman, & MacCoun, 2008) but,

480   whilst four- and five-year-olds are able to make accurate judgements regarding knowledge

481   and accuracy independently, they are unable to discredit models that exhibit inconsistencies

482   between knowledge and accuracy (Tenney, Small, Kondrad, Jaswal, & Spellman, 2011).

483   This, again, supports the notion that children can process single model-based biases but find

484   the calibration of multiple biases challenging. There is perhaps a cognitive cost associated

485   with model-based biases; some model-based biases, such as a bias towards pedagogical cues,

486   may be automatic and dominate in younger children even when more relevant model

487   characteristics, such as proficiency, are available.

488

489   **Summary**

490   We have highlighted some of the cognitive skills required for children to employ

491   model-based biases. Many of these skills develop in the first five years of a child's life and

492   are a vital part of a child's social cognition; for example, monitoring affect and perspective

493   taking. Other cognitive skills enable children to move beyond employing model-based biases,

494   to evaluating these biases. This leads to flexibility in their use by understanding context,

495   assessing specialists and generalists, tracking prior personal experience and calibrating

496   multiple biases. These abilities require other cognitive skills such as language and working

497   memory. Additionally, many of these cognitive skills show a developmental shift and require

498 experience. Development increases flexibility in the use of model-based biases that allows

499 children to move beyond simple biases to evaluating context as well as a model's behaviour.

500

501 **Section 3: Future directions**

502

503   Here, we suggest avenues of investigation of model-based biases beyond our

504 argument of their adaptive value and exploration of their development. Specifically, we focus

505 on the emerging argument that social learning and, potentially, model-based biases are not

506 solely based on individuals acquiring the best environmental information and that model-

507 based biases may not always lead to the most adaptive behaviour. Following this, we

508 highlight the usefulness of a comparative perspective, demonstrating that model-based biases

509 in non-human animals show both convergences and divergences with that of children.

510

511 **Understanding the social side of model-based biases**

512   This review has deliberately focussed on the adaptive value of model-based biases,

513 arguing that preferentially copying certain models will lead to learning the most adaptive

514 behaviour for one's environment. However, we accept that we have assumed that the

515 behaviours copied are primarily functional (e.g. tool use or culturally appropriate). However,

516 to-be learnt behaviour may also be inherently social, and social interaction is an additional or

517 alternative function of imitation (Grusec, & Abramovitch, 1982; Over & Carpenter, 2012;

518 Užgiris, 1981). Therefore, an interesting future direction would be to focus on the interplay

519 between social and functional motivations to copy within the context of model-based biases.

520 For example, as seen in the previous section, children's model-based biases change if the to-

521 be-copied behaviour becomes more social (e.g. play) than functional (Zmyj et al., 2011).

522 Investigating model-based biases in the context of how the content of the modelled behaviour

523 affects the use of model-based biases would shed more light on whether the same biases are

524 employed differently when the domain of the to-be-copied behaviour varies.

525   Additionally, it would be interesting to explore model-based biases which focus on

526 the social behaviour of models, building upon work showing that how socially engaging a

527 model is can affect whether children copy her or him (Elekes & Kiraly, 2012; Nielsen, 2006;

528 Nielsen, Simcock, & Jenkins, 2008). Nielsen (2006) and Nielsen & Blank (2011) argue that

529 this is due to a social motivation to share an experience or create an affiliation and that

530 certain social, or indeed anti-social behaviours, influence the copying of functional

531 behaviours. Furthermore, witnessing scenarios involving third-person ostracism can increase

532 imitation in children (Over & Carpenter, 2009). This last example, whilst not demonstrating a

533 model-based bias, does suggest that the model-based biases in the previous examples may be

534 a by-product of an emotional reaction to a social situation rather than an evolutionary

535 adaption. Of course, such behaviour might be both an emotional reaction and adaptive, in that

536 pro-social behaviour is thought to be an evolutionary adaption (Dawkins, 1989). Thus

537 children may be biased towards copying models that are pro-social both in order to obtain

538 pro-social traits and because pro-social behaviour offers a degree of prestige.

539

540 **Understanding when model-based biases may not be adaptive**

541   As mentioned in the introduction, social learning is not seen as universally adaptive

542 and there may also be instances whereby a model-based social learning strategy is not

543 inherently adaptive. For example, a bias towards copying a model that is successful in one

544 domain might lead to other, non-adaptive behaviours, also being copied from this model, a

545 phenomenon that is often used in advertising through celebrity endorsements. This

546 "piggybacking" (Mesoudi & O'Brien, 2008, p 23) of non-adaptive behaviour from a

547 particular model could lead to maladaptive behaviour. An example of this is the copying of

548 causally irrelevant actions demonstrated by an adult, but not a child, model (Wood, et al.,

549 2012). The potential side effects of model-based biases need to be better understood in order

550 to understand their pervasiveness and development.

551

552 **Comparative research**

553 It is interesting to see whether model-based biases are unique to humans. A

554 comparative perspective is also useful to developmental research as the presence or absence

555 of particular biases may shed light on what cognitive skills (present or absent in other

556 species) are necessary and/or sufficient for model-based biases to be used. The adaptive

557 nature of model-based biases has been discussed in relation to non-human animals'

558 (henceforth animals) social learning (Laland, 2004) and there has been a surge of activity

559 directed at identifying and understanding the variety of biases that might influence social

560 learning in animals (Kendal, Coolen, van Bergen, & Laland, 2005; Rendell et al., 2011).

561 Work with animals demonstrates some interesting convergences with children. For example,

562 in line with proposition 1, both dogs (Range, Viranyi, & Huber, 2007) and chimpanzees

563 (Buttelmann, Carpenter, Call, & Tomasello, 2007) seem able to assess a model's intentions,

564 and are more likely to copy unusual behaviour when it seems intentional. Both these species

565 are social animals perhaps suggesting a link between social cognition and this bias.

566 In line with proposition 2, that children are biased towards copying the most

567 proficient models, capuchin monkeys prefer to observe more successful models although

568 there was no evidence that this increased their copying of one model over another (Ottoni, de

569 Resende, & Izar, 2005). Kendal et al (submitted) fitted statistical models to chimpanzees'

570 interactions with an extractive foraging advice and found some evidence that chimpanzees

571 copy expert individuals. Investigating this proposition in animals seems like a fruitful avenue.

572 More research has been conducted with animals regarding proposition 3, that children are

573 biased towards models belonging to a group that may have a reputation for being more

574 proficient; stickleback fish copy the feeding location of older, larger fish as opposed to

575 smaller, younger fish (Duffy et al., 2009). Mice are more influenced by the food choices of

576 adult mice over younger mice (Choleris, Guo, Liu, Mainardi, & Valsecchi, 1997) and young

577 female guppies copy the mate choice of older versus younger female guppies (Amlacher &

578 Dugatkin, 2005). Wild chimpanzees show selective attention towards observing models of

579 the same age or older, but not younger, than themselves (Biro et al., 2003), and captive

580 chimpanzees' copying of food retreival methods is influenced more by older versus younger

581 individuals (Horner, Proctor, Bonnie, Whiten, & de Waal, 2010). The bredth of species that

582 show this bias indicates that it is a relatively cognitively simple model-based bias to process.

583   In line with proposition 4, some animals are biased towards models who are more

584 gentically similar to themselves (rats; Saggerson & Honey, 2006) and more familiar (fish;

585 Swaney, Kendal, Capon, Brown, & Laland, 2001), again suggesting that this may be a salient

586 model-based bias. Finally, with regard to proposition 5, some animals are biased towards

587 individuals with high status; dominant individuals appear to elicit social learning more than

588 subordinates in a wide variety of species (e.g. chimpanzees, Bonnie, Horner, Whiten, & de

589 Waal, 2007, Horner et al., 2010; capuchins, Dindo, Thierry, & Whiten, 2008; hens, Nicol &

590 Pope, 1994, 1999; and seals, Sanvito, Galimberti, & Miller, 2007). However, the degree to

591 which this is analogous to a copying high-status individuals bias in children depends upon the

592 degree to which high-status represents aggressive force (power) or deference (prestige) in

593 human and non-human species. Work with animals also offers some interesting

594 interpretations for these biases. For example in lemurs, dominant individuals were more

595 likely to be copied, as they monopolised resources (Kendal et al., 2010) and thus provided the

596 most demonstrations. In children non-monopolization of resources has been seen (Flynn &

597 Whiten, 2012) yet the bias remained; the dominant children were watched out of choice.

598   Another interesting interpretation from animal research is that increased social

599   learning from a particular model may not always be due to model-based biases, but instead be

600   due to an attentional by-product. Benskin, Mann and Lachlan (2002) and Katz and Lachlan

601   (2003) suggest that female finches copy the feeding location of male rather than female

602   conspecifics because females pay attention to males as potential mates, while females do not

603   need to attend to one another. Conversely, male finches show no feeder preference because

604   male finches pay equal attention to males (as potential rivals) and females (as potential

605   mates). Likewise, male canaries are more innovative and better at personally learning a new

606   feeding behaviour, but behaviours demonstrated by the females are more likely to be copied

607   as the males are aggressive towards male observers (Cadieu, Fruchard, & Cadieu, 2010).

608   Lastly, wild vervet monkeys learn to retreive more food from an artificial fruit task when the

609   task is modelled successfully by a female rather than a male, possibly because of females'

610   tolerance of observer presence (van de Waal, Renevey, Favre, & Bshary, 2010) or their

611   likelihood, as the philopatric sex, of possessing relevant knowledge.

612   This body of work on animals suggests that model-based biases are not unique to

613   humans. However, what may be unique to humans is the flexibilty with which biases are used

614   through children's developing ability to be receptive to pedagogical cues (Call & Tomasello,

615   1999), perspective take (Brosseau-Liard & Birch, 2011), categorise and generalise

616   proficiency (Koenig & Jaswal, 2011), assess context (Zmyj et al., 2011) and calibrate

617   multiple model-based biased (Jaswal & Neely, 2006), not to mention our species'

618   understanding of complex language and higher-order mental state understanding (Jaswal &

619   Malone, 2007). Alternatively, what could be unique to humans is that copying serves a social

620   as well as a functional motivation, as outlined above (Nielsen, 2009). Animals may have the

621   ability to categorise and generalise proficiency, or callibrate multiple model-based biases, and

622   these are avenues that need further investigation.

623

Conclusions

624

625   Children are prolific social learners, adopting the language, tool-use, knowledge and

626   beliefs of those around them. We have highlighted that children do not source information

627   indiscriminately, but rather use biases to guide their copying of others' behaviour. What

628   makes children's social learning truly impressive is their ability to implement strategies of

629   model-based biases. These biases are adaptive in that they enable children to source the 'best'

630   trait variant without the cost of assessing every trait variant displayed within the environment.

631   Whilst some biases seem automatic, children need a suite of cognitive skills to use other

632   model-based biases. These cognitive abilities are not all necessary for the occurrence of

633   model-based biases, but they all assist in ensuring model-based biases are effective, because

634   they enhance children's appraisals of models and allow children to flexibly evaluate the

635   context. Model-based biases and some of the accompanying cognitive skills required to learn

636   and maintain these biases are not unique to humans. However, the combination of model-

637   based biases and children's development of species-unique socio-cognitive skills (Dean,

638   Kendal, Schapiro, Thierry, & Laland, 2012; Whiten & Erdal, 2012), such as language and

639   understanding another's mental states, means that children stand alone in their ability to

640   source the right model for them, in the right context, and use this model's behaviour to guide

641   their own behaviour; resulting in a uniquely adaptive form of social learning. Research into

642   model-based biases now needs to go beyond identifying the presence and direction of model-

643   based biases and move towards an understanding of the relationship between specific

644   cognitive skills and the emergence and development of individual biases and the interaction

645   (and potential changeable hierarchies) of different model-based biases.

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