

1 Social information use and social information waste

2

3 Olivier Morin^{1,2}, Pierre Olivier Jacquet³, Krist Vaesen⁴, Alberto Acerbi⁵

4

5 c. 8200 words

6

7 1. Institut Jean Nicod, DEC, ENS, EHESS, CNRS, PSL University, UMR 8129, Paris.

8 2. Minds and Traditions Research Group, Max Planck Institute for the Science of Human
9 History, Jena, Germany.10 3. Laboratoire de Neurosciences Cognitives et Computationnelles (LNC2), Département
11 d'Etudes Cognitives, INSERM, Ecole Normale Supérieure, PSL Research University, Paris,
12 France.13 4. School of Innovation Sciences, Eindhoven University of Technology, Eindhoven, The
14 Netherlands

15 5. Centre for Culture and Evolution, Brunel University, London, UK.

16

17 **Abstract.** Social information is immensely valuable. Yet we waste it. The information we get
18 from observing other humans and from communicating with them is a cheap and reliable
19 informational resource. It is considered the backbone of human cultural evolution. Theories and
20 models focused on the evolution of social learning show the great adaptive benefits of evolving
21 cognitive tools to process it. In spite of this, human adults in the experimental literature use
22 social information quite inefficiently: they do not take it sufficiently into account. A
23 comprehensive review of the literature on five experimental tasks documented 45 studies
24 showing social information waste, and 4 studies showing social information being over-used.
25 These studies cover “egocentric discounting” phenomena as studied by social psychology, but
26 also include experimental social learning studies. Social information waste means that human
27 adults fail to give social information its optimal weight. Both proximal explanations and
28 accounts derived from evolutionary theory leave crucial aspects of the phenomenon unaccounted
29 for: egocentric discounting is a pervasive effect that no single unifying explanation fully
30 captures. Cultural evolutionary theory’s insistence on the power and benefits of social influence
31 is to be balanced against this phenomenon.

32

33 **Keywords:** Egocentric discounting, social learning, cultural evolution, imitation, epistemic
34 vigilance, information cascades, conformity, advice-taking, judge-advisor-system.

35

36 1. Introduction

37

38 The human capacity to use social information is fundamental to our species’ cultural evolution—
39 arguably humankind’s key adaptive asset [1–4]. It affords enormous cognitive benefits, allowing
40 individuals to avoid the costs of individual exploration, and most importantly, to avail

41 themselves of collective progresses no individual could have made on their own. One is naturally
42 tempted to infer that humans evolved both uncommon capacities for using social information,
43 and an uncommon degree of dependence on it. Leading specialists of cultural evolution embrace
44 this view, drawing on alleged cases of over-reliance on the example of others, such as the
45 imitation of kamikaze suicides [5] or celebrity suicides [4,6], and the copying of prestigious
46 models in domains where these models are clearly incompetent [7]. However, several
47 experimental results, including from the cultural evolution research tradition, suggest that
48 individuals (this paper focuses on human adults) use social information sub-optimally.
49 Specifically, they do not use it enough.

50
51 Social information consists in all the things that an individual can learn from others, be it through
52 intentional communication, demonstrations, or the mere observation of behaviours that are not
53 necessarily meant to be seen [1,8]. We use social information whenever we let it affect our
54 behaviour. Alongside social information, we routinely process large amounts of non-social
55 information. Here we'll call it "individual": primary perceptions that come to us directly from the
56 world, neither coming from nor mediated by other people. Individual information has one clear
57 advantage over social information: it comes to us processed by no filter but our own sensory
58 nervous system. Social information is processed or produced by others before we process it,
59 which can cause distortions due to random error, bias, or deliberate deception.

60
61 In a social world, individual information acquires two new uses.

62
63 First, each agent's individual information can be combined with others agents' individual
64 information, producing "wisdom of crowds" effects. When several agents produce two
65 independent (i.e., not influenced by or copied from the other agent) guesses on a state of the
66 world, and if (for binary decisions) each individual agent is more likely to be right than wrong,
67 the combination of their guesses through majority voting or averaging usually gives a far more
68 reliable guess than any single answer [9–11]. This well-known result only holds, however, to the
69 extent that individual guesses are independent from each other: each guess must reflect
70 individual information [12,13].

71
72 Second, possessing a piece of information that is not (or not yet) social may give one an edge in
73 strategic relations with conspecifics. Disclosed to others, it enhances one's reputation as a
74 reliable informant and valuable cooperator [14]. Kept to oneself, it makes it possible to reap
75 rewards that elude others [15]. Both types of information (the social and the asocial) thus have
76 their advantages and drawbacks. How much weight should we give to individual or social
77 information, and how much effort should we spend acquiring one or the other?

78
79 Experimental evidence from several independent research traditions has evidenced a surprising
80 discrepancy between efficiency rules for social information use, and human participants' actual

81 behaviour. Contrary to what one might expect from a cultural species, participants appear to put
82 too little weight on the information they can gather from other people's decisions or testimony.
83 In each of the literatures we survey, the relevant findings are relatively uncontroversial: we do
84 not claim to be discovering anything that is not already known. However, researchers in one field
85 do not necessarily know about all the findings from other fields. As a result, the pervasiveness of
86 egocentric discounting is not always fully realised. Furthermore, no single field possesses an
87 integrated account of why it occurs in its multiple manifestations. The present paper precisely
88 aims at filling this lacuna, proceeding in three steps. Part 2 synthesises the available experimental
89 evidence for the overweighting of individual information relative to social information,
90 surveying social psychology, cultural evolution, and experimental economics. In Part 3, we
91 discuss the putative proximate factors that have been put forward to explain this effect: cognitive
92 biases, task-specific demands, biases in participants sampling. In Part 4, we discuss some
93 ultimate factors that one can derive from theories or models about social learning's evolutionary
94 history. In conclusion (part 5), our survey reveals that no single explanation taken in isolation
95 captures all the aspects of the phenomenon.

96

97 **2. How much does social information weigh in our decisions?**

98

99 The supplementary materials present a list of publications that specifically document how
100 experimental participants (focusing exclusively on human adults) give less weight to social
101 information when it conflicts with a belief that they hold based on previous knowledge, or with a
102 piece of private information provided by the experimenters to them but not to others. A
103 comprehensive list of inclusion criteria is given in Section 1 of the Supplementary Materials.
104 These are studies in which participants are asked to perform a task, having access to both
105 individual and social information. Pieces of information of both kinds are potentially relevant to
106 the task, but often conflict. What counts as success in the task is clearly defined, and there are
107 widely accepted normative frameworks that specify how agents should behave to succeed.
108 Accurate performance, as opposed to agreement with other participants, is valued (usually
109 incentivised). The participants are presented with social information, usually concerning the
110 other participants' responses, freely or at a small cost.

111

112 The exact criteria for what constitutes rational or efficient use of social information vary
113 depending on authors, protocols, or studies, but some basic criteria are shared by all. First, the
114 opinion of two random participants should be given equal weights. Second, absent suspicions of
115 deceptive intent or noisy transmission, other people's opinion should not be given less weight
116 merely because they come from others. These two principles imply that the average random
117 participant should give equal weight to her opinion and to that of a random participant from the
118 same group [16]. This basic principle can be formalised in various ways, the most common being
119 Bayesian updating rules [17–22] or the averaging heuristic [16,23]. This point of view is not
120 universally shared. Hawthorne-Madell and Goodman [24] defend a somewhat more relaxed view

121 of what counts as a rational use of social information. Their model does not place *a priori*
122 restrictions on the degree of competence that an agent should attribute to a random unknown
123 agent. If an agent believes themselves to be more knowledgeable and reliable than others, it is
124 rational for them to discount others' opinions. Indeed, under this assumption, the very fact that
125 others disagree with the agent is evidence that their advice shouldn't be trusted [24]. This model,
126 however, does not explain why an agent would believe themselves to be better informed and
127 more reliable than any random agent, on a topic that neither agent is especially competent about.
128

129 We did a comprehensive search of the literature on five experimental tasks, detailed below.
130 Overall, between 45 (counting only clear cases) and 49 (counting ambiguous cases, see Supp.
131 Mat. Section 1 on what counts as a ambiguous case) of the studies we collected show that
132 participants clearly fail to give enough weight to social information, showing excessive reliance
133 on their own information, a phenomenon known as “egocentric discounting” in the advice-taking
134 literature [25]. We re-use this label, here, to name a phenomenon that goes far beyond advice-
135 taking experiments. In contrast, we found only 3 publications (5 if we include two ambiguous
136 cases) showing a bias in the other direction or an absence of bias. This review is no quantitative
137 proof, but it is in line with the consensus view in the publications we surveyed (See
138 supplementary materials, in particular section 1 on inclusion criteria). Evidence for egocentric
139 discounting, which consists in giving individual information greater weight than would be
140 normatively warranted, comes from at least three independent research traditions (social
141 psychology, cultural evolution-inspired experiments, and behavioural economics). In all three,
142 egocentric discounting came up as a surprise discovery—at least not one that previous theorising
143 had predicted. These studies mainly use five broad types of tasks.
144

145 *The advice-taking paradigm.* The standard form of this task is the “Judge-Advisor System” [26],
146 but we also consider studies that do not use this exact paradigm, or do not explicitly do so, as
147 well as studies from the forecast combination literature [27,28]. In a typical advice-taking task,
148 the participant is asked to make a quantitative judgement on a factual question (e.g. “What is the
149 height of Mount Everest?”). Having given this first answer, they are confronted with another
150 participant's answer, and allowed to give a second answer. Accurate answers are usually (but not
151 always) incentivized (incentives tend to decrease the egocentric discounting effect without
152 eliminating it) [29]. The main variants involve presenting the participant with the other estimate
153 before asking them for their own, presenting the participant with an average of the group's
154 estimate, or allowing discussions between participants. The normative strategy in such tasks, for
155 the second answer, is to average, i.e., to move halfway towards the other participant's guess [28],
156 unless one has reasons to think the advisor is clearly more (or less) knowledgeable than oneself.
157 All the studies we gathered find evidence of egocentric discounting, at least in their baseline
158 condition: the participants' second guess modifies their first guess in the direction of the
159 advisor's guess, but gives much more weight to the participant's first guess than to the advisor's.
160 Table 1 in the supplementary materials shows weight of advice (WOA) values (or similar

161 measures) for 40 experiments across 17 publications. All 40 studies document a WOA below
162 0.5, consistent with egocentric discounting, in one condition at least (usually the baseline
163 condition). Egocentric discounting can be modulated by changing the participants' confidence in
164 their own answer and their perception of the advisor's expertise, but all this happens against a
165 baseline of heavy discounting.

166

167 *Two-armed bandit problems with social learning.* In a typical task, a participant must choose
168 between two options, A and B, one of which yields greater rewards on average. The payoff
169 function linking A or B to the attached rewards is noisy, so that the best response can only be
170 detected after a certain amount of exploration. Participants are typically informed about their
171 rewards on each trial, with a piece of individual (and usually, private) information, but they are
172 also informed about other participants' choices. This information may concern one participant, a
173 few, or all previous participants, it may or may not include the feedback that these participants
174 received, it may or may not be available for free. Given this variation, there is not one single
175 optimal strategy for taking social information into account in all these tasks, and even inside a
176 given task, what would constitute optimal use cannot always be straightforwardly determined.
177 Nevertheless, six studies show clear cases of egocentric discounting (vs. only one showing clear
178 evidence of the opposite effect). In [30]'s "Best Color" condition, the option that gave the best
179 payoff for the majority of participants on the previous round is announced, yet the model that
180 best fits the data does not include social information. In [31], participants in the "social learning"
181 condition are not given any individual feedback on their own responses, but they are told what
182 the majority of participants chose in another condition, where those participants were given
183 feedback. This information is under-used, resulting in sub-optimal choices. (Specifically, 12 out
184 of 40 participants, self-described non-conformists, ignore it altogether.) In [32] (experiment 2),
185 participants sometimes or (for 20 participants out of 55) always refuse to view a piece of
186 information about others' choices that is made freely available and would have improved
187 decisions if followed. In experiment 3 of the same study, a conformist strategy (imitating what
188 the majority of participants did on the previous rounds) is consistently optimal but not
189 consistently followed by participants, who tend to prefer relying on their own private
190 information. Importantly, learning based on non-social information is, in these studies, highly
191 effective (e.g. [31]). In other words, participants have no difficulty updating their behaviour
192 when the feedback consists in individual (rather than social) information. This suggests that
193 general difficulties with belief updating cannot explain social information under-use in these
194 tasks.

195

196 *"Virtual arrowheads" experiments.* These experiments, developed by Mesoudi and his group
197 (e.g. [33,34]) can be seen as a many-dimensional version of a multi-armed bandit task.
198 Participants devise, via a computer interface, arrowheads that are used for simulated "hunts", and
199 rewarded depending on their hunts' success. Hunting success is a function of the arrowhead's
200 properties (a range of parameters that participants determine). Although [35] found that

201 participants readily consulted and used social information when given the opportunity to view
202 the choices of other players for free, requiring participants to pay for this information clearly
203 pushes them to rely on their own feedback instead. In subsequent studies where participants must
204 choose between getting feedback on their own hunts and seeing other people’s choices of
205 arrowhead parameters, they choose the former, even though choosing the latter is more
206 beneficial [33,34,36].

207
208 In the last two types of tasks, a participant must guess a given state of the world on the basis of
209 cues provided by the experimenter, and may be given, in addition to these cues, information on
210 other participants’ choices (one or more). This general description fits both the use of cue-based
211 learning paradigms in the advice-taking and social learning literatures [37–40], and the “ball-
212 and-urn” task used by behavioural economists to simulate cascades (e.g. [17], and see sup. mat.).
213 In addition to the cues, participants may be given feedback regarding the accuracy of their
214 choices, but in “ball-and-urn” studies, no feedback is given until rewards are disclosed at the end
215 of the task.

216
217 *Cue-based learning.* These studies, inspired by advice-taking tasks, differ from advice-taking
218 tasks in one essential respect. Instead of basing their guesses on general knowledge, the subjects
219 have access to a series of experimentally controlled cues. The subject makes a first guess on the
220 basis of these cues, then makes a second (possibly revised) guess after being exposed to social
221 information (either an expert’s guess, or a peer’s guess, or a group’s average guess). Once again,
222 participants fail to update their first guess as much as they should [37–39]. Here again we only
223 looked for positive evidence for egocentric discounting, or for the opposite effect. We do not
224 include studies whose design may have allowed them to capture egocentric discounting, but
225 which do not mention it among their findings, possibly because they did not look for it. Possible
226 examples include [40,41].

227
228 *Ball-and-urn tasks.* In a typical *ball-and-urn task* (see sup. mat. for more information), the
229 experiment starts with the experimenter randomly picking one out of two urns. Each urn contains
230 balls of different colours, one urn having more balls of colour A, the other urn more balls of
231 colour B. Participants, playing one after the other, are each given a ball drawn (with
232 replacement) from the chosen urn. They must guess which of the two urns is being used,
233 knowing that one urn contains more balls of colour A, the other more balls of colour B. (The
234 ratio of A/B balls in each urn is typically known to the participants.) In addition to seeing the
235 colour of their own ball (individual information), each participant knows the guesses made by
236 everyone else before them. The studies in this group are the least straightforward to interpret,
237 because of issues surrounding the normative criteria that apply to the task. To determine the
238 weight that a participant should give to the decisions of the preceding participants, assumptions
239 need to be made regarding their rationality, the probability that they err randomly, and the weight
240 that they themselves put on their predecessors’ decisions. Standard models, based on rational
241 choice (in the specific sense of Bayesian updating) and game-theoretic equilibria [42,43], assume

242 that all agents update their beliefs in a fully normative way, and know that other agents also do.
243 Yet experimental participants do not behave in the normative way, as these models make clearly
244 false predictions [43,44]. Since standard models are normatively valid for an agent only if other
245 agents behave as the model say they should, which they do not, using them as a normative
246 benchmark is questionable. Several alternative ways to prove egocentric discounting coexist in
247 the literature. One consists in showing that a simple “private information” model, where
248 participants take no account whatsoever of social information and only rely on their individual
249 information, outperforms more complex model like the Bayes-Nash model [45–47]. Another is
250 to demonstrate that participants overweigh their private information both relative to the optimal
251 Bayes-Nash model but also relative to more realistic models, like the Quantal Response
252 Equilibrium model [48]. Perhaps the most concrete demonstration comes from showing how
253 much of the possible payoff participants forego by relying on private information (an important
254 amount, while almost no payoff is lost from following social information) [44,49]. Together,
255 these different lines of circumstantial evidence converge to show that participants in these tasks
256 generally underuse social information.

257

258

259 **3. Proximate explanations for egocentric discounting**

260

261 Many potential explanations have been put forward to explain egocentric discounting [3,29,50].
262 A generally endorsed explanation is that people put less trust in socially acquired information
263 than in individual information [29,51]. This explanation is not trivial. It does exclude some
264 possible causes, for instance a general inability to revise one’s opinions in the face of
265 information of whatever nature. There is a general consensus that egocentric discounting is
266 different from, and stronger than, a simple inability to update our beliefs [27,29]. Belief updating
267 in human adults is not optimal, but consistent evidence for a clear bias in favour of one’s prior
268 opinion is lacking [52]. In most of the “bandit” and “arrowhead” tasks, participants get private
269 feedback on their actions, which they take into account in a near-optimal way, contrasting with
270 their poor use of social information [31,53]. Likewise, participants in advice-taking tasks use
271 new evidence efficiently when it is not social [16,22]. Self-confidence is a reliable predictor of
272 egocentric discounting [29]: indeed, as Hawthorne-Madell & Goodman show, it is rational (in
273 the authors’ specific sense) for a self-confident agent to discount divergent opinions. However,
274 simply saying that people fail to place as much trust in other informants as they place in
275 themselves eschews the main question. Why do we not trust others as much as we ought to?

276

277 *Lack of ecological validity.* The value of social information may be higher in experiments than it
278 is in real life. According to a common critique of the experimental psychology of decision-
279 making, subjects tackle laboratory tasks with a series of heuristics adapted to real-life
280 circumstances that need not obtain in the lab, leading to a mere appearance of irrationality [54].
281 Is there evidence that people fail to profit from social information optimally outside the lab?

282 Non-laboratory evidence that people fail to trust social information as much as would be useful
283 for them includes studies of vaccine refusal, climate change skepticism, and resistance to mass
284 persuasion attempts (synthesised in [55]). The experiments reviewed here represent a wide range
285 of methodologies, some highly controlled, others much closer to everyday experience. Among
286 the most ecologically relevant, the early experiments on forecast updating grew from ergonomic
287 research [37,56,57] What these studies ask of their subjects is little different from what they
288 would do in the ordinary course of their life: update an epidemiological forecast or a medical
289 treatment forecast, based on another opinion. Experiments in the advice-taking literature also
290 place subjects in a fairly ordinary situation, that of updating one's estimate for a date (e.g. a
291 historical or news event), a quantity (e.g., a price), given someone else's estimate. It is not clear
292 how these tasks depart from ordinary situations in such a systematic way as to explain pervasive
293 egocentric discounting.

294

295 *Culture.* One popular explanation among cultural evolutionists explains egocentric discounting
296 as an effect of culturally inculcated individualistic values [1,36,58]. Individualistic cultural
297 learning is thought to be a “Western” phenomenon, absent in some cultures at least: China, Japan
298 or Korea [1,59], or small-scale societies relying on pastoralism (according to [58]). However,
299 clear evidence for egocentric discounting has been found in both groups. Egocentric discounting
300 was documented in Japanese [60,61] and Chinese participants [20,36,62], and in a group of
301 executives from 24 different nationalities [28]. While some studies find stronger rates of
302 egocentric discounting in East Asian participants as opposed to Western ones [61], others do not
303 [20,60]. In [36], only one sample of East Asian participants shows higher reliance on social
304 learning, but the other two do not. Pastoralists in [58] show less discounting of social
305 information compared to horticulturalists or city-dwellers, but they still discount it, as do the
306 Altiplano pastoralists studied in [30]. Overall, the literature shows some evidence for cultural
307 modulations of egocentric discounting, but does not support seeing it as a Western peculiarity.
308 Geographical differences may also be determined by external factors (rather than culturally
309 transmitted ideologies). For instance, experiencing economic and psychosocial adversity seems
310 to increase reliance on social information [63].

311

312 *Access to reasons.* One standard explanation in the advice-taking literature holds that participants
313 trust their own views more because they have access to their reasons for those views [16,64].
314 There are, however, reasons to doubt that this is a necessary condition. Results show that
315 egocentric discounting occurs even when participants are asked to revise an estimate without
316 being given access to the cues that motivated the estimate [65] and that egocentric discounting is
317 also observed when participants are presented with someone else’s opinion, falsely presented as
318 their own [27,66]: they put more weight than they ought to on opinions that are presented as their
319 own.

320

321 *Task engagement.* In most of the studies we reviewed, participants may be more actively
322 involved in processing or producing individual information, than in receiving advice. Active
323 engagement in a task promotes learning in a way that passive observation does not, arousing the
324 participants' attention to a greater extent and allowing them to encode information in distinctive
325 ways [67]. In "two-armed bandit" and "arrowheads" tasks, the level of engagement is often
326 strikingly higher for individual information: the nature of the feedback that participants receive is
327 a direct consequence of their intentional actions, whereas social information is produced by
328 others. In some of these tasks, participants may decide whether or not they want to see others'
329 choices, but the extent of their active involvement with social information ends there. In most
330 advice-taking tasks, the participants actively generate their personal estimate, and are then
331 passively exposed to someone else's. Could this explain egocentric discounting in such cases?
332 Partly, but once again it fails to explain why egocentric discounting obtains when participants are
333 presented with someone else's opinion falsely presented as their own [27,66]. The best argument
334 against an account of egocentric discounting based on the participants' active involvement may
335 come from ball-and-urn tasks, where both individual and social information consist in passively
336 received cues. Social information remains discounted. It is worth noting, however, that in
337 experiments where social information has to be actively requested, instead of being passively
338 presented, subjects are prone to request too much social information [68,69], even when that
339 information is worthless [70].

340
341 *An anchoring effect in advice-taking tasks.* These tasks typically ask a participant to formulate
342 their own guess for a quantitative or numerical question, then to update it after being exposed to
343 someone else's guess. These are favourable conditions for an anchoring effect to occur.
344 Anchoring effects happen when a piece of information biases an estimate because all subsequent
345 estimates are referred to it and weighed in its direction, to a greater extent than they should be,
346 and even when the piece of information is completely irrelevant — for instance, a random
347 number [71]. In one sense, egocentric discounting truly *is* a type of anchoring effect: the
348 participants' initial estimate is given excessive weight, preventing them from updating their
349 guess as much as they should. However, there are good reasons to reject the view that the general
350 mechanisms at work in the anchoring effect explain egocentric discounting [27,29,65,72]. One
351 reason is that an egocentric effect still obtains when participants complete a number of unrelated
352 numerical estimation tasks between their first estimate and their last estimate, which should
353 cancel any priming effect [27]. Furthermore, telling participants that an estimate is their own is
354 sufficient to trigger egocentric discounting in favour of that estimate, even when the estimate is
355 not actually their own, and is presented for the first time [27,66]. If egocentric discounting rested
356 on a mere anchoring effect, labelling estimates as one's own or others should not matter. See
357 [73] for an exploration of the possible role of anchoring mechanisms in advice-taking more
358 generally.

359

360 *Low exploration rates in “bandit” and “arrowhead” tasks.* In these two types of tasks,
361 participants must update their behaviour in response to feedback, in a simulated environment
362 where the payoff associated with each response is noisy, and may change over time. In some of
363 these experiments, environmental changes are faster than in habitual real-life situations. A failure
364 to adjust to the rapid rates of these changes could lead to conservatism, i.e., a tendency to stick to
365 the solution one chose on previous trials (or remain close to it) instead of changing to the
366 (correct) solution available with social learning. Two studies show a correlation between
367 exploratory behaviour and social learning. In the "social and individual learning condition" of
368 [34] (Experiment 2), changes in the up-coming responses were greater for participants who opted
369 to copy a model than for those who did not. In [74] participants in the "social learning"
370 condition, who could see the solutions that other participants gave to the task, were more
371 explorative than participants in the individual learning condition, who could not. The data in [34]
372 in particular raise the possibility that participants neglected social information because of a
373 general aversion to exploration (in [74], it is not clear whether participants under-use social
374 information). However, neither study establishes causation. In [74], the availability of social
375 information is experimentally manipulated and controlled, so high exploration must be a
376 consequence of social learning—not its cause. Another study that experimentally manipulates the
377 availability of social information, and finds that social information induces a greater level of
378 exploration, is [50]. Here again, greater explorativeness cannot *cause* social learning. Both
379 studies suggest that relations between exploration and social learning, when present, are likely to
380 reflect an effect of social information upon exploratory behaviours, rather than the opposite. (See
381 [75] for additional evidence against a causal link between exploratory behaviour and social
382 information use).

383
384

385 **4. Evolutionary explanations for egocentric discounting**

386

387 The mechanisms discussed in the previous sections have to do with the specifics of experimental
388 situations, from participant selection to task demands. We now move on to possible explanations
389 for egocentric discounting that see it as a functional and adaptive feature of the way we deal with
390 social information.

391

392 *Epistemic vigilance.* Trouche et al. [66] interpret egocentric discounting through the lens of
393 Sperber et al.’s epistemic vigilance framework [76]. In this view, human adults have an *a priori*
394 reluctance to believe communicated information, unless accompanied by arguments or other
395 guarantees of reliability. This default vigilance serves as a protection against attempted
396 manipulation [76]. A straightforward implication seems to be that social information will be less
397 readily accepted when a source intentionally communicates it, rather than letting it leak
398 inadvertently. Yet, it is unclear whether participants in the experiments we just reviewed usually
399 perceive social information as being intentionally communicated to them by the source. With a

400 few exceptions [77], social information is merely introduced as another participant’s opinion,
401 leaving it unspecified whether the participant intended their opinion to be shown, or even knew
402 that it would be. The same is true of most two-armed bandit tasks, arrowhead experiments, and
403 cue-based learning tasks: social information is eavesdropped by its recipient, not openly
404 communicated by its source. The major exception are “ball-and-urn” experiments, where
405 participants know that their answers will be made public to all subsequent participants [17,44].
406 Contrary to what epistemic vigilance might imply, this seems to cause participants to trust social
407 information *more*, not less. Participants in ball-and-urn tasks tend to answer in ways that are
408 helpful for others (but possibly harmful for themselves). Working with a task similar in its main
409 features to the ball-and-urn tasks, [78] argue that participants are aware of this, and show that
410 participants are more likely to follow their predecessor’s advice than to imitate their action—the
411 opposite of what epistemic vigilance would suggest. This piece of counter-evidence is merely
412 suggestive: testing the epistemic vigilance hypothesis would require experiments that make it
413 clear to participants whether other participants intentionally produced social information for
414 other participants to use.

415

416 *A producer-scrounger dilemma for information use.* Social information is only useful when
417 others also gather information asocially. Cultural-evolutionary models contain a possible
418 explanation of egocentric discounting. Rogers’ influential model [79] showed that social learning
419 may not provide any advantage over individual learning when the environment changes. The
420 advantage of using social learning depends on the frequency of social learners in the population:
421 if those are too numerous, social learning is useless. When there are mostly individual learners,
422 copying is effective, because it saves the costs of individual exploration, and because the
423 probability of copying a correct behaviour is high. However, when there are mostly social
424 learners, the risk of copying an outdated behaviour increases and individual learners are
425 advantaged. This means the advantages of social-learning are inversely frequency-dependent: the
426 more other people learn socially, the less efficient it is to learn from them. The same logic is
427 reflected, on a smaller scale, in models of information cascades, where social learning can (with
428 a small probability) become detrimental for an individual when too many other individuals resort
429 to it. More generally, a broad range of models converge upon the view that social information
430 use can be likened, in terms of evolutionary game theory, to a producer-scrounger dynamic
431 [35,75,80]. At equilibrium, these games typically yield a mixed population of producers
432 (individual learners) and scroungers (social learners), where neither type does better than the
433 other [81,82]. Egocentric discounting might emerge from a producer-scrounger dilemma, as a
434 response to the devaluation of social information which may occur when too many other agents
435 rely on social learning.

436

437 This hypothesis potentially explains several phenomena related to egocentric discounting. A
438 frequency-dependent equilibrium could account for egocentric discounting in a subset of
439 experimental participants [83]. These participants could be wasting social information for two

440 reasons, a strategic one and an altruistic one. The strategic reason starts from the premise that
441 other participants rely excessively on social learning, making it hazardous to follow them. On a
442 more altruistic account, egocentric discounting may be a way to help the community of
443 participants with first-hand information [50]. Egocentric discounting, in this perspective, is
444 altruistic: it increases the amount of information circulating in a group, at the cost of making the
445 discounter less accurate [42]. Only two studies, to our knowledge, address the possible effect of
446 altruistic motivations on egocentric discounting. In Eriksson & Strimling [50], subjects who
447 scored high on a prosocial attitudes survey (Social Value Orientation scale) showed a greater
448 propensity to acquire individual as distinct from social information, although [69] fails to find an
449 impact of self-reported altruistic tendencies on subjects' preferences for social or private
450 information. A "producer-scrounger equilibrium" account may also explain the widely
451 documented inter-individual heterogeneity in propensities for social learning [53,75,84,85] since
452 such an equilibrium is based upon the coexistence of two opposite strategies. However, this
453 account leaves several questions unanswered, which future work might address.

454
455 - How do we explain egocentric discounting at the aggregate level? The experiments we review
456 document egocentric discounting effects at the level of entire groups of subjects. Even though
457 inter-individual variation, when explored, can be large, the discarding of social information is not
458 driven by a minority, and it is not compensated, overall, by an equally strong tendency in the
459 opposite direction. Why are there so few information scroungers?

460
461 - Do egocentric discounters expect others to over-rely on social information, and why? The
462 producer-scrounger dilemma account appears to assume that people waste social information
463 because they assume (consciously or not) that others are too reliant on it, making it less useful.
464 But in most of the studies we reviewed the opposite holds true: most participants rely too little on
465 social information, not too much.

466
467

468 **5. Conclusion**

469
470 There is little doubt that our species relies a great deal on social information, and that cultural
471 transmission would be impossible if we did not use it [7,76,86]. This makes the well-known
472 phenomenon of egocentric discounting all the more puzzling. This paper documented it across
473 five different experimental paradigms (going beyond standard cases of egocentric discounting in
474 the advice-taking literature). Several independent research traditions uncovered different aspects
475 of the same phenomenon, a phenomenon that none of them had predicted. Combining the results
476 of a diverse range of tasks allows for a better assessment of the most common explanations. Our
477 review highlights the difficulty of explaining away egocentric discounting with any single-cause
478 account, and stresses the need to study egocentric discounting through the lenses of the multiple
479 research traditions that have investigated it. Those complement each other. Social psychology is

480 strong on ecological validity. Cultural evolution research seeks diverse subject pools of
481 participants. Experimental economics is weaker on both these counts, but cascade experiments
482 provides evidence against mechanisms that play a role in other paradigms: for instance, task
483 engagement or epistemic vigilance.

484
485 A closer look at egocentric discounting also addresses a long-running debate in cultural
486 evolutionary theory. A long-standing critical argument rightly stresses the artificial nature of the
487 distinction between social and individual learning [87,88]. Social learning, as the critics point
488 out, need not be anything but individual learning from social cues: humans require no special-
489 purpose adaptation, no dedicated cognitive module to learn from others. We fully agree with this
490 stance, with one subtle difference. Individual and social information may be processed by the
491 same mechanisms, but not on an equal footing. The information that one gets on one's own
492 engages our attention differently; it is more tractable and traceable than information that comes
493 to us filtered through others' minds. Because it is acquired independently, it is also of more use
494 to others than second-hand information.

495
496 Cultural evolution, alongside social psychology and experimental economics, has done much to
497 document and explore the fact that socially acquired information may be given less weight than
498 equivalent individual information. No extant theory predicts this phenomenon in all its
499 dimensions or in a straightforward way. An exciting next step could consist in drawing the
500 cultural consequences of our reluctance to incorporate information: how it impacted the
501 evolution of social learning in our evolutionary past, and the diffusion of culture throughout our
502 history.

503
504 **Electronic Supplementary Material:** Accessible at [URL to be added after peer-review].
505 [Appended to this submission.]

506
507 **Funding.** This work has received funding from the "Frontiers in Cognition" EUR grant, ANR-
508 17-EURE-0017 EUR. P.O.J. was supported by ANR-10-IDEX-0001-02 PSL.

509
510 **References**

- 511
512 1. Mesoudi A, Chang L, Dall SRX, Thornton A. 2016 The Evolution of Individual and Cultural
513 Variation in Social Learning. *Trends Ecol. Evol.* **31**, 215–225.
514 (doi:10.1016/j.tree.2015.12.012)
- 515 2. Muthukrishna M, Morgan TJH, Henrich J. 2016 The when and who of social learning and
516 conformist transmission. *Evol. Hum. Behav.* **37**, 10–20.
517 (doi:10.1016/j.evolhumbehav.2015.05.004)
- 518 3. Morgan TJH, Rendell LE, Ehn M, Hoppitt W, Laland KN. 2012 The evolutionary basis of
519 human social learning. *Proc. R. Soc. B Biol. Sci.* **279**, 653–662.
520 (doi:10.1098/rspb.2011.1172)

- 521 4. Henrich J. 2015 *The Secret of Our Success: How Culture Is Driving Human Evolution,*
522 *Domesticating Our Species, and Making Us Smarter*. Princeton: Princeton University Press.
- 523 5. Boyd R, Richerson P. 1985 *Culture and the evolutionary process*. Chicago: The university of
524 Chicago Press.
- 525 6. Mesoudi A. 2009 The Cultural Dynamics of Copycat Suicide. *PLOS ONE* **4**, e7252.
526 (doi:10.1371/journal.pone.0007252)
- 527 7. Richerson P, Boyd R. 2005 *Not by genes alone*. Chicago: The University of Chicago Press.
- 528 8. Danchin É, Giraldeau L-A, Valone TJ, Wagner RH. 2004 Public information: from nosy
529 neighbors to cultural evolution. *Science* **305**, 487–491.
- 530 9. Lorge I, Fox D, Davitz J, Brenner M. 1958 A survey of studies contrasting the quality of group
531 performance and individual performance, 1920-1957. *Psychol. Bull.* **55**, 337–372.
532 (doi:10.1037/h0042344)
- 533 10. Galton F. 1907 Vox Populi. *Nature* **75**, 450–451.
- 534 11. Condorcet. 1785 *Essai sur l'application de l'analyse à la probabilité des décisions*
535 *rendues à la pluralité des voix*. Paris: L'imprimerie royale.
- 536 12. Mercier H, Morin O. 2019 Majority rules: how good are we at aggregating convergent
537 opinions? *Evol. Hum. Sci.* **1**. (doi:10.1017/ehs.2019.6)
- 538 13. Lorenz J, Rauhut H, Schweitzer F, Helbing D. 2011 How social influence can undermine
539 the wisdom of crowd effect. *Proc. Natl. Acad. Sci.* **108**, 9020–9025.
540 (doi:10.1073/pnas.1008636108)
- 541 14. Boyer P. 2018 *Minds Make Societies: How Cognition Explains the World Humans*
542 *Create*. New Haven, CT: Yale University Press.
- 543 15. Giraldeau L-A, Valone TJ, Templeton JJ. 2002 Potential disadvantages of using socially
544 acquired information. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* **357**, 1559–1566.
545 (doi:10.1098/rstb.2002.1065)
- 546 16. Yaniv I. 2004 Receiving other people's advice: Influence and benefit. *Organ. Behav.*
547 *Hum. Decis. Process.* **93**, 1–13. (doi:10.1016/j.obhdp.2003.08.002)
- 548 17. Anderson LR, Holt CA. 1997 Information Cascades in the Laboratory. *Am. Econ. Rev.*
549 **87**, 847–862.
- 550 18. Whalen A, Griffiths TL, Buchsbaum D. 2018 Sensitivity to Shared Information in Social
551 Learning. *Cogn. Sci.* **42**, 168–187. (doi:10.1111/cogs.12485)
- 552 19. Pescetelli N, Yeung N. 2019 The role of decision confidence in advice-taking and trust
553 formation. *ArXiv180910453 Cs*
- 554 20. Mahmoodi A *et al.* 2015 Equality bias impairs collective decision-making across cultures.
555 *Proc. Natl. Acad. Sci.* **112**, 3835–3840. (doi:10.1073/pnas.1421692112)

- 556 21. Leong YC, Zaki J. 2018 Unrealistic optimism in advice taking: A computational account.
557 *J. Exp. Psychol. Gen.* **147**, 170–189. (doi:10.1037/xge0000382)
- 558 22. De Filippis R, Guarino A, Jehiel P, Kitagawa T. 2016 Updating ambiguous beliefs in a
559 social learning experiment.
- 560 23. Larrick RP, Soll JB. 2006 Intuitions About Combining Opinions: Misappreciation of the
561 Averaging Principle. *Manag. Sci.* **52**, 111–127. (doi:10.1287/mnsc.1050.0459)
- 562 24. Hawthorne-Madell D, Goodman ND. 2019 Reasoning about social sources to learn from
563 actions and outcomes. *Decision* **6**, 17–60. (doi:10.1037/dec0000088)
- 564 25. Yaniv I, Kleinberger E. 2000 Advice Taking in Decision Making: Egocentric Discounting
565 and Reputation Formation. *Organ. Behav. Hum. Decis. Process.* **83**, 260–281.
566 (doi:10.1006/obhd.2000.2909)
- 567 26. Sniezek JA, Buckley T. 1995 Cueing and cognitive conflict in Judge-Advisor decision
568 making. *Organ. Behav. Hum. Decis. Process.* **62**, 159–174. (doi:10.1006/obhd.1995.1040)
- 569 27. Harvey N, Harries C. 2004 Effects of judges' forecasting on their later combination of
570 forecasts for the same outcomes. *Int. J. Forecast.* **20**, 391–409.
571 (doi:10.1016/j.ijforecast.2003.09.012)
- 572 28. Soll JB, Larrick RP. 2009 Strategies for revising judgment: how (and how well) people
573 use others' opinions. *J. Exp. Psychol. Learn. Mem. Cogn.* **35**, 780–805.
574 (doi:10.1037/a0015145)
- 575 29. Bonaccio S, Dalal RS. 2006 Advice taking and decision-making: An integrative literature
576 review, and implications for the organizational sciences. *Organ. Behav. Hum. Decis. Process.*
577 **101**, 127–151. (doi:10.1016/j.obhdp.2006.07.001)
- 578 30. Efferson C, Richerson PJ, McElreath R, Lubell M, Edsten E, Waring TM, Paciotti B,
579 Baum W. 2007 Learning, productivity, and noise: an experimental study of cultural
580 transmission on the Bolivian Altiplano. *Evol. Hum. Behav.* **28**, 11–17.
581 (doi:10.1016/j.evolhumbehav.2006.05.005)
- 582 31. Efferson C, Lalive R, Richerson PJ, McElreath R, Lubell M. 2008 Conformists and
583 mavericks: the empirics of frequency-dependent cultural transmission. *Evol. Hum. Behav.* **29**,
584 56–64. (doi:10.1016/j.evolhumbehav.2007.08.003)
- 585 32. McElreath R, Lubell M, Richerson PJ, Waring TM, Baum W, Edsten E, Efferson C,
586 Paciotti B. 2005 Applying evolutionary models to the laboratory study of social learning. *Evol.*
587 *Hum. Behav.* **26**, 483–508. (doi:10.1016/j.evolhumbehav.2005.04.003)
- 588 33. Mesoudi A. 2011 An experimental comparison of human social learning strategies:
589 payoff-biased social learning is adaptive but underused. *Evol. Hum. Behav.* **32**, 334–342.
590 (doi:10.1016/j.evolhumbehav.2010.12.001)
- 591 34. Acerbi A, Tennie C, Mesoudi A. 2016 Social learning solves the problem of narrow-
592 peaked search landscapes: experimental evidence in humans. *R. Soc. Open Sci.* **3**, 160215.
593 (doi:10.1098/rsos.160215)

- 594 35. Mesoudi A. 2008 An experimental simulation of the “copy-successful-individuals” cultural
595 learning strategy: adaptive landscapes, producer–scrounger dynamics, and informational
596 access costs. *Evol. Hum. Behav.* **29**, 350–363. (doi:10.1016/j.evolhumbehav.2008.04.005)
- 597 36. Mesoudi A, Chang L, Murray K, Lu HJ. 2015 Higher frequency of social learning in China
598 than in the West shows cultural variation in the dynamics of cultural evolution. *Proc. R. Soc.*
599 *B Biol. Sci.* **282**, 20142209. (doi:10.1098/rspb.2014.2209)
- 600 37. Harvey N, Fischer I. 1997 Taking Advice: Accepting Help, Improving Judgment, and
601 Sharing Responsibility. *Organ. Behav. Hum. Decis. Process.* **70**, 117–133.
602 (doi:10.1006/obhd.1997.2697)
- 603 38. Läpplé D, Barham BL. 2019 How do learning ability, advice from experts and peers
604 shape decision making? *J. Behav. Exp. Econ.* **80**, 92–107. (doi:10.1016/j.socec.2019.03.010)
- 605 39. Novaes Tump A, Wolf M, Krause J, Kurvers RHJM. 2018 Individuals fail to reap the
606 collective benefits of diversity because of over-reliance on personal information. *J. R. Soc.*
607 *Interface* **15**, 20180155. (doi:10.1098/rsif.2018.0155)
- 608 40. Puskaric M, von Helversen B, Rieskamp J. 2017 How social and non-social information
609 influence classification decisions: A computational modelling approach. *Q. J. Exp. Psychol.*
610 *2006* **70**, 1516–1534. (doi:10.1080/17470218.2016.1192209)
- 611 41. Collins EC, Percy EJ, Smith ER, Kruschke JK. 2011 Integrating advice and experience:
612 learning and decision making with social and nonsocial cues. *J. Pers. Soc. Psychol.* **100**,
613 967–982. (doi:10.1037/a0022982)
- 614 42. Bikhchandani S, Hirshleifer D, Welch I. 1998 Learning from the Behavior of Others:
615 Conformity, Fads, and Informational Cascades. *J. Econ. Perspect.* **12**, 151–170.
- 616 43. Kübler D, Weizsäcker G. 2005 Are Longer Cascades More Stable? *J. Eur. Econ. Assoc.*
617 **3**, 330–339.
- 618 44. Weizsäcker G. 2010 Do We Follow Others when We Should? A Simple Test of
619 Rational Expectations. *Am. Econ. Rev.* **100**, 2340–2360.
- 620 45. Çelen B, Kariv S. 2004 Distinguishing Informational Cascades from Herd Behavior in the
621 Laboratory. *Am. Econ. Rev.* **94**, 484–498.
- 622 46. Çelen B, Kariv S. 2005 An experimental test of observational learning under imperfect
623 information. *Econ. Theory* **26**, 677–699. (doi:10.1007/s00199-004-0542-0)
- 624 47. Noth M, Weber M. 2003 Information Aggregation with Random Ordering: Cascades and
625 Overconfidence. *Econ. J.* **113**, 166–189.
- 626 48. Goeree JK, Palfrey TR, Rogers BW, McKelvey RD. 2007 Self-Correcting Information
627 Cascades. *Rev. Econ. Stud.* **74**, 733–762.
- 628 49. Ziegelmeyer A, March C, Kruegel S. 2013 Do We Follow Others when We Should? A
629 Simple Test of Rational Expectations: Comment. *Am. Econ. Rev.* **103**, 2633–2642.

- 630 50. Eriksson K, Strimling P. 2009 Biases for acquiring information individually rather than
631 socially. *J. Evol. Psychol.* **7**, 309–329. (doi:10.1556/JEP.7.2009.4.4)
- 632 51. Krueger x. 2003 Return of the ego--self-referent information as a filter for social
633 prediction: comment on Karniol (2003). *Psychol. Rev.* **110**, 585–90; discussion 595.
634 (doi:10.1037/0033-295x.110.3.585)
- 635 52. Tversky A, Kahneman D. 1982 Evidential impact of base rates. In *Judgment under*
636 *Uncertainty: Heuristics and Biases* (eds A Tversky, D Kahneman, P Slovic), pp. 153–160.
637 Cambridge: Cambridge University Press. (doi:10.1017/CBO9780511809477.011)
- 638 53. Toelch U, Bruce MJ, Newson L, Richerson PJ, Reader SM. 2014 Individual consistency
639 and flexibility in human social information use. *Proc. R. Soc. B Biol. Sci.* **281**, 20132864.
640 (doi:10.1098/rspb.2013.2864)
- 641 54. Gigerenzer G, Goldstein DG. 1996 Reasoning the fast and frugal way: Models of
642 bounded rationality. *Psychol. Rev.* **103**, 650–669. (doi:10.1037/0033-295X.103.4.650)
- 643 55. Mercier H. 2020 *Not Born Yesterday: The Science of Who We Trust and What We*
644 *Believe*. Princeton University Press.
- 645 56. Gardner PH, Berry DC. 1995 The effect of different forms of advice on the control of a
646 simulated complex system. *Appl. Cogn. Psychol.* **9**, S55–S79. (doi:10.1002/acp.2350090706)
- 647 57. Lim JS, O'Connor M. 1995 Judgemental adjustment of initial forecasts: Its effectiveness
648 and biases. *J. Behav. Decis. Mak.* **8**, 149–168. (doi:10.1002/bdm.3960080302)
- 649 58. Glowacki L, Molleman L. 2017 Subsistence styles shape human social learning
650 strategies. *Nat. Hum. Behav.* **1**, 0098. (doi:10.1038/s41562-017-0098)
- 651 59. Nisbett R. 2004 *The Geography of Thought: How Asians and Westerners Think*
652 *Differently...and Why*. Simon and Schuster.
- 653 60. Jayles B, Kim H, Escobedo R, Cezera S, Blanchet A, Kameda T, Sire C, Theraulaz G.
654 2017 How social information can improve estimation accuracy in human groups. *Proc. Natl.*
655 *Acad. Sci.* **114**, 12620–12625. (doi:10.1073/pnas.1703695114)
- 656 61. Mercier H, Yama H, Kawasaki Y, Adachi K, Henst J-BV der. 2012 Is the Use of
657 Averaging in Advice Taking Modulated by Culture? *J. Cogn. Cult.* **12**, 1–16.
658 (doi:10.1163/156853712X633893)
- 659 62. Wang X, Du X. 2018 Why Does Advice Discounting Occur? The Combined Roles of
660 Confidence and Trust. *Front. Psychol.* **9**. (doi:10.3389/fpsyg.2018.02381)
- 661 63. Jacquet PO, Safra L, Wyart V, Baumard N, Chevallier C. In press. The ecological roots
662 of human susceptibility to social influence: a pre-registered study investigating the impact of
663 early-life adversity. *R. Soc. Open Sci.* **6**, 180454. (doi:10.1098/rsos.180454)
- 664 64. Yaniv I, Choshen-Hillel S. 2012 Exploiting the Wisdom of Others to Make Better
665 Decisions: Suspending Judgment Reduces Egocentrism and Increases Accuracy. *J. Behav.*
666 *Decis. Mak.* **25**, 427–434. (doi:10.1002/bdm.740)

- 667 65. Soll JB, Mannes AE. 2011 Judgmental aggregation strategies depend on whether the
668 self is involved. *Int. J. Forecast.* **27**, 81–102. (doi:10.1016/j.ijforecast.2010.05.003)
- 669 66. Trouche E, Johansson P, Hall L, Mercier H. 2018 Vigilant conservatism in evaluating
670 communicated information. *PLoS ONE* **13**. (doi:10.1371/journal.pone.0188825)
- 671 67. Gureckis TM, Markant DB. 2012 Self-Directed Learning: A Cognitive and Computational
672 Perspective. *Perspect. Psychol. Sci. J. Assoc. Psychol. Sci.* **7**, 464–481.
673 (doi:10.1177/1745691612454304)
- 674 68. Çelen B, Hyndman K. 2012 Social Learning Through Endogenous Information
675 Acquisition: An Experiment. *Manag. Sci.* (doi:10.1287/mnsc.1110.1506)
- 676 69. Duffy J, Hopkins E, Kornienko T, Ma M. 2019 Information choice in a social learning
677 experiment. *Games Econ. Behav.* **118**, 295–315.
- 678 70. Goeree JK, Yariv L. 2015 Conformity in the lab. *J. Econ. Sci. Assoc.* **1**, 15–28.
679 (doi:10.1007/s40881-015-0001-7)
- 680 71. Tversky A, Kahneman D. 1974 Judgment under Uncertainty: Heuristics and Biases.
681 *Science* **185**, 1124–1131. (doi:10.1126/science.185.4157.1124)
- 682 72. Schultze T, Mojzisch A, Schulz-Hardt S. 2017 On the Inability to Ignore Useless Advice.
683 *Exp. Psychol.* **64**, 170–183. (doi:10.1027/1618-3169/a000361)
- 684 73. Rader CA, Larrick RP, Soll JB. 2017 Advice as a form of social influence: Informational
685 motives and the consequences for accuracy. *Soc. Personal. Psychol. Compass* **11**, e12329.
686 (doi:10.1111/spc3.12329)
- 687 74. Derex M, Feron R, Godelle B, Raymond M. 2015 Social learning and the replication
688 process: an experimental investigation. *Proc. R. Soc. B Biol. Sci.* **282**, 20150719.
689 (doi:10.1098/rspb.2015.0719)
- 690 75. Toyokawa W, Saito Y, Kameda T. 2017 Individual differences in learning behaviours in
691 humans: Asocial exploration tendency does not predict reliance on social learning. *Evol.*
692 *Hum. Behav.* **38**, 325–333. (doi:10.1016/j.evolhumbehav.2016.11.001)
- 693 76. Sperber D, Clément F, Heintz C, Mascaro O, Mercier H, Origgi G, Wilson D. 2010
694 Epistemic Vigilance. *Mind Lang.* **25**, 359–393. (doi:10.1111/j.1468-0017.2010.01394.x)
- 695 77. Swol LM van. 2009 The effects of confidence and advisor motives on advice utilization.
696 *Commun. Res.* **36**, 857–873. (doi:10.1177/0093650209346803)
- 697 78. Çelen B, Kariv S, Schotter A. 2010 An Experimental Test of Advice and Social Learning.
698 *Manag. Sci.* **56**, 1687–1701. (doi:10.1287/mnsc.1100.1228)
- 699 79. Rogers AR. 1988 Does Biology Constrain Culture? *Am. Anthropol.* **90**, 819–831.
700 (doi:10.1525/aa.1988.90.4.02a00030)

- 701 80. Kameda T, Nakanishi D. 2002 Cost–benefit analysis of social/cultural learning in a
702 nonstationary uncertain environment An evolutionary simulation and an experiment with
703 human subjects. *Evol. Hum. Behav.* , 21.
- 704 81. Dall S, Giraldeau L, Olsson O, Mcnamara J, Stephens D. 2005 Information and its use
705 by animals in evolutionary ecology. *Trends Ecol. Evol.* **20**, 187–193.
706 (doi:10.1016/j.tree.2005.01.010)
- 707 82. Laland KN. 2004 Social learning strategies. *Anim. Learn. Behav.* **32**, 4–14.
708 (doi:10.3758/BF03196002)
- 709 83. Kameda T, Nakanishi D. 2003 Does social/cultural learning increase human
710 adaptability? Rogers’s question revisited. *Evol. Hum. Behav.* **24**, 242–260.
711 (doi:10.1016/S1090-5138(03)00015-1)
- 712 84. Olsen K. In press. Knowing whom to learn from: individual differences in metacognition
713 and weighting of social information.
- 714 85. Molleman L, van den Berg P, Weissing FJ. 2014 Consistent individual differences in
715 human social learning strategies. *Nat. Commun.* **5**, 3570. (doi:10.1038/ncomms4570)
- 716 86. Sterelny K. 2012 *The Evolved Apprentice: How evolution made humans unique*. Boston:
717 MIT Press.
- 718 87. Heyes C. 1993 Imitation, culture and cognition. *Anim. Behav.* **46**, 999–1010.
- 719 88. Sterelny K. 2006 The Evolution and Evolvability of Culture. *Mind Lang.* **21**, 137–165.
720 (doi:10.1111/j.0268-1064.2006.00309.x)
- 721