

Prestige and content biases together shape the cultural transmission of narratives

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1 Abstract

2 Context-based cultural transmission biases such as prestige are thought to have been a primary
3 driver in shaping the dynamics of human cultural evolution. However, few empirical studies have
4 measured the importance of prestige relative to other effects, such as the content biases present
5 within transmitted information. Here, we report the findings of an experimental transmission study
6 designed to compare the simultaneous effects of a high- or low-prestige model with the presence
7 of content containing social, survival, emotional, moral, rational, or counterintuitive information.
8 Results from multimodel inference reveal that prestige is a significant factor in determining
9 salience and recall, but that several content biases, specifically social, survival, negative
10 emotional, and biological counterintuitive information, are significantly more influential. Further,
11 we find evidence that prestige serves as a conditional learning strategy when no content cues are
12 available. Our results demonstrate that content biases serve a vital and underappreciated role in
13 cultural transmission.

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16 Introduction

17

18 Storytelling is a powerful and universal tool that humans use to know and understand the world^{1,2},
19 to preserve history and traditional knowledge^{3,4}, to educate^{5,6}, to persuade^{7,8}, and to heal^{9,10}.
20 Stories encode complex cultural and ecological information, and have the capability to endure for
21 at least 7,000 years^{11,12}, and possibly much longer¹³. In addition, skilled storytelling may increase
22 an individual's reproductive fitness^{14,15} and social value, as well as promoting cooperation within
23 groups¹⁵. Stories can be an efficient and effective vector for information transfer¹⁶, and an
24 established body of literature in the interdisciplinary field of cultural evolution suggests that the
25 success or failure of a story and its component parts are determined by the mechanisms of
26 biased cultural transmission^{17–22}.

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28

The extent to which cultural selection, by way of biased transmission, is the primary
factor responsible for cultural change is a central and enduring debate within cultural evolution^{23–}

29 26. Cultural selection theory argues that cultural diversity is largely shaped by direct and indirect
30 cognitive biases that unconsciously drive the selection of cultural variants over successive
31 transmission events^{27–29}. In the absence of these transmission biases, cultural learning is unlikely
32 to be more advantageous than individual learning^{30–32}. In this study, we provide a realistic
33 approach to studying cultural change through investigating the relative effects of an array of
34 competing biases within the transmission of narrative stories. This framework allows us to gain a
35 better understanding of the microevolutionary processes that have shaped and continue to shape
36 human culture.

37 Despite the critical role that transmission biases appear to play in driving cultural
38 evolution, critical gaps exist in our understanding of the relative strengths of these biases^{25,33–35}.
39 In particular, prior experimental studies have tended to focus on individual biases, yet multiple
40 biases are always present simultaneously^{19,21,36–38}. Narratives are especially dense in information
41 that contains a number of proposed content-based or “direct” biases²⁸ that have been shown to
42 aid in the salience and retention of information^{20,39–42}.

43 Content biases influence transmission through properties of the information itself that
44 make it more appealing and memorable²⁸. These preferences for certain types of information can
45 vary between individuals and across cultures, but some have been seen to be remarkably
46 consistent⁴³. Here, we conduct the first simultaneous test of the relative effects of the most
47 frequently cited content biases from the cultural evolution literature. This includes content linked
48 to the following six types of information: (i) *social*, either in the sense of everyday basic social
49 interaction or of “gossip” about third parties^{20,21}; (ii) *survival*, for environmental contexts relevant
50 to individual fitness^{21,41,44}; (iii) *emotional*, that elicits strong positive or negative responses such as
51 disgust^{19,40,45,46}; (iv) *moral*, regarding acceptable behavior and social norms^{19,47}, which has not
52 been previously studied explicitly using transmission experiments; (v) *rational*, describing cause-
53 and-effect connections⁴⁸; and (vi) *counterintuitive*, which defies ontological expectations in
54 biological, physical, mental, and other domains^{39,49}. Additionally, counterintuitive information can
55 influence transmission in different ways: by themselves, counterintuitive elements can be more
56 salient than other types of information³⁹; or, collectively, a minority of counterintuitive elements
57 can lead to a minimally counterintuitive (“MCI”) bias that enhances overall recollection of a
58 story^{22,50}. We crafted the narratives used in this study to resemble real-world creation stories in
59 both form and the aforementioned types of content biases (see Methods). Real-world creation
60 stories have evolved over many generations of transmission and selection, and therefore tend to
61 contain biased content at high frequencies.

62 Beyond the types of information included in a story, learners are also sensitive to the
63 identity and reputation of the storyteller. These transmission biases are referred to as context-
64 based biases, and include model-based or “indirect”²⁸ biases such as *prestige*⁵¹, *success*⁵², and
65 *similarity*^{53,54}, and frequency-dependent *conformity* and *anti-conformity* biases⁵⁵. In this study, we
66 specifically examine prestige bias, which involves a preference to learn from individuals of high
67 social position, reputation, and knowledge⁵⁶. Prestige bias is one of the most commonly cited
68 transmission biases³⁵, and has been implicated as one of the predominant forces in cultural
69 change^{51,57,58}. However, the limited empirical work to date has shown mixed support regarding
70 the extent to which the prestige of a model actually affects the adoption of a particular cultural
71 variant or behavior^{38,59–61} (see ³⁵ for a recent general review on the topic).

72 We use regional accents of speech as an experimental cue for prestige information. As
73 has been established within the field of sociolinguistics^{62–66}, and verified by two of our previous
74 studies^{56,67}, listeners perceive accents as strong indicators of prestige. Accents are hard-to-fake
75 signals⁶⁸ and tend to be stable over time. Therefore, some varieties become associated with
76 membership in high-status groups^{63,69–71}. These perceptions of accent are consistent with how
77 prestige is understood in cultural evolution studies. Accent thus provides a methodological
78 alternative to the use of attention, gaze, or group consensus to represent prestige, which

79 potentially suffer from flaws tied to the ambiguity and context dependency of these signals^{26,72–74}.
80 In our experiment, we present stories aurally and ask for oral recall rather than written responses
81 in order to limit the number of distinct cognitive domains involved.

82 Humans are highly attuned to the biases present in the information we consume and to
83 the identities of potential cultural models that hold that information. Here, we address multiple
84 gaps in the literature by explicitly quantifying learners' recall of multiple distinct types of content,
85 transmitted by speakers with varying levels of prestige. By testing content and context biases
86 together in the experimental transmission of a narrative, we can examine the relative effects of a
87 large suite of biases: biases that theory suggests shape the spread of information and the
88 evolution of human culture.

91 Results

92
93 **Participants showed preferential recall of biased information.** Of the 87,421 narrative
94 propositions we presented in total, participants recalled 12,505 (14.3%) (Supplementary Table 1).
95 We found a significant difference between the proportions of content types presented and the
96 proportions of content types recalled (two-sided permutation test of independence: $z = -2.037$, $p =$
97 0.042), showing that participants recalled some types of biased information more frequently than
98 other types, including unbiased information (i.e. propositions that did not contain any of the
99 examined content biases; **Fig. 1**).

100 Recall for each type of content bias ranged from a mean of 6.6% of the propositions
101 presented (moral) to 33.9% (biological counterintuitive). In general, we observed small but non-
102 significant differences in the recall of content biases in high- versus low-prestige speaker
103 conditions (**Fig. 2**). However, corrected pairwise comparisons of proportions (Supplementary
104 Table 2) showed that prestige had a significant impact on the recall of unbiased information ($p <$
105 0.001) and basic social information ($p = 0.001$). Additionally, participants recalled unbiased
106 information significantly less often than biased information under the same prestige condition,
107 except for positive emotional, moral, rational, and physical and mental counterintuitive
108 information. Of these, positive emotional, moral, and mental counterintuitive information were
109 recalled significantly less frequently than unbiased information.

110
111 **Content biases were more influential than prestige bias.** To explain the variance in recall of
112 specific propositions, we fit a total of 58 proposed models using maximum likelihood estimation
113 (Supplementary Table 3). Models included different combinations of variables for story-based
114 effects, the high or low prestige condition, the presence or absence of each content bias, and
115 participant demographics (see Methods for a full list). Eleven of the best-fitting models had a
116 resulting ΔAIC score < 2 , indicating no single “best” model exists. The majority of best-fitting models
117 included variables for story presentation order, for prestige, social, survival, negative emotional,
118 and counterintuitive biases, and for gender and working memory (Supplementary Table 4).

119 Our results (**Fig. 3**; Supplementary Table 5) show that the transmission biases with the
120 greatest effect on recall were, in descending order: counterintuitive (but only for biological
121 violations), negative emotional, social, survival, and prestige. All other biases had negligible effects
122 according to their model-averaged coefficients and confidence intervals and their relative variable
123 importance values. Though we did find a significant effect for prestige, it was the weakest of the
124 transmission biases, with an odds ratio of 1.164 (95% CI [1.113, 1.217]) compared to the next
125 lowest, survival, with 1.858 (95% CI [1.216, 2.841]) and to the strongest effect, biological
126 counterintuitive, with 7.558 (95% CI [3.913, 14.597]). For story effects, participants had better recall
127 for the second story they were presented, regardless of which story it was. The placement of

128 propositions within the story had no effect on recall. For demographic variables, only working
129 memory had a significant positive effect.

130

131 **Transmission biases explain little variance in recall.** The set of best-fitting models ($\Delta\text{AIC} < 2$)
132 had relatively high mean conditional R^2_{GLMM} values at 0.524 ($SD < 0.001$), but a lower marginal
133 R^2_{GLMM} at 0.106 ($SD = 0.002$). The difference between the two values represents the proportion of
134 the variance explained by the random effects of the model, which were the participant ID (i.e.
135 individual differences) and proposition number. Comparisons of the lowest-AIC model with ones
136 excluding either random effect using likelihood-ratio tests were both significant (participantID $X^2 [1]$
137 $= 6526.1$; proposition $X^2 [1] = 9728.2$; both $p << 0.001$), indicating that the individual participant and
138 proposition effects were both influential. These results tell us that there is a great deal of variance
139 in our responses that is not accounted for by the transmission biases and other fixed effects
140 included in the models. Further, they indicate that this unexplained variance exists both among the
141 participants and within the content of the stories.

142

143

144 Discussion

145

146 **Prestige bias has a minor effect on transmission.** We found significant positive effects for
147 prestige, social, survival, negative emotional, and biological counterintuitive biases on recall (see
148 **Fig. 3**; Supplementary Table 5). Prestige-biased transmission has been prominent in the cultural
149 evolution literature^{28,35,36,51,75–79}. However, prestige bias as proxied by accent had the smallest
150 effect on transmission, increasing the likelihood of a proposition's recall by only 15%. One
151 possible explanation for the secondary importance of prestige concerns the nature of the
152 narratives transmitted. Transmission biases can lead to the development of group markers and
153 ingroup cooperation^{53,80,81}, and creation stories are representative of a shared group identity¹⁵.
154 We propose that if the audience does not perceive some cultural relationship between
155 themselves and the storyteller or narrative, prestige may be a less pertinent cue for social
156 learning. Prestige often exists as an ingroup hierarchy with less relevance to outgroup
157 individuals^{58,82}.

158 Assuming that shared identity could be a factor mediating the efficacy of prestige bias—in
159 effect, a similarity bias⁵³—we examined links between participant and storyteller demographics.
160 We would predict from this argument that participants should better recall a narrative read by a
161 speaker whose accent they could personally identify with. However, our results show no effect on
162 recall from matching participants' childhood location with the region of the low-prestige speaker's
163 accent ("childhood town low prestige," see **Fig. 3**). We included other potential effects of similarity
164 bias through the standardization of speaker demographics and the inclusion of participants'
165 demographics in the models (see Methods). However, we found no significant associations
166 between recall and similarity of participants' identities with those of the speakers.

167

168 **Prestige is unconsciously employed as a secondary bias.** Another potential explanation for
169 the low importance of prestige in determining recall is that participants may adjust their social
170 learning strategies depending on which biases are present in different parts of the narrative^{33,37,83}.
171 When content biases were present, prestige had less relative influence on recall, but participants
172 tended to recall unbiased propositions more frequently when the narrative was told by a speaker
173 with a high-prestige accent (**Fig. 2**).

174 The finding that prestige takes a secondary role to content supports the conclusion of the
175 only other experimental study we know to have compared prestige and content³⁸. In that study,
176 the authors found that the effects of prestige were minimal compared to content effects (in the
177 form of "inspiration" or general likability rather than specific biases) when rating their preference

178 for quotations from famous or unknown authors. We suggest that, together, the results of the
179 previous study and our own demonstrate the importance of content biases in directing cultural
180 transmission. These content cues can be more nuanced than general context-based copying
181 rules such as prestige, but our results show that content biases can take a primary role over
182 context. Future studies can seek to understand how the relative importance of content versus
183 context biases may vary across different sociocultural contexts and the potential interactive
184 effects between different forms of biases (e.g., one character feeding another may encode both
185 social and survival information, and be more or less salient than either type of content
186 individually).

187

188 **Content biases have distinct effects.** As previously noted, we found that the effects of content
189 types on information transmission varied widely (**Fig. 3**). Although we might have expected a
190 greater attention to “gossip” over basic social interactions²⁰, the lack of a significant difference
191 between the two in our results (**Fig. 2**) could be due to variation in how we operationalized the
192 concept of gossip. In this study, gossip was qualified by the presence of third parties in social
193 interactions and not by the subjective intensity of interaction as has been done previously²⁰.
194 Furthermore, as entire narratives have been ascribed as gossip in previous work²⁰, any recall in
195 those studies was attributed to this bias, whereas we coded specific propositions with social
196 interaction as either basic or gossip. The advantageous impact of social “gossip” on transmission
197 also may have been tempered by the cognitive load of processing multiple levels of theory of
198 mind in these interactions^{84,85}.

199 Our results also support multiple prior empirical studies that found strong positive effects
200 on transmission for survival information^{21,41,44,86}, and for negative emotional information but not
201 positive emotional information^{18,19,87}. Indeed, negative emotional information was found to be one
202 of the most powerful biases in our stories (**Fig. 2**). As negative information arouses strong
203 emotional responses such as fear, disgust, and anger, some theorize that humans evolved broad
204 cognitive domains receptive to negative information as a survival response to predators and toxic
205 food sources^{88–92}, which may explain why both survival and negative emotional information are
206 particularly salient.

207 We did not find evidence to support effects from moral, rational, or most counterintuitive
208 information on transmission. Moral and mental counterintuitive information (as well as positive
209 emotional, above) were actually recalled less often than unbiased information (**Fig. 2**), though not
210 enough to lead to negative odds ratios when accounting for other variables (**Fig. 3**). However,
211 there have been few prior tests of these biases within an experimental transmission paradigm.
212 For instance, previous evidence of a bias for “rational” or causal information in this context has
213 been anecdotal⁹³, though related work has focused on causal reasoning and imitation^{94–97}. The
214 transmission of rational information relies upon the retention of a predicate, hence, rational bias
215 may affect the recall of surrounding information but may not be reliably recorded. Further, we
216 defined successful transmission of rational information as requiring the retention of the
217 subordinating conjunction (“because,” “so that,” “when,” etc.; the proposition coded as having
218 rational content), which may explain the lack of an effect. Hence, rational bias may have had a
219 proximity effect on the recall of surrounding information, without being recalled itself, that was not
220 detected by our present analyses.

221 For moral information, according to social norm theory, individuals should be expected to
222 retain and transmit moral information depending, firstly, on the strength of the social norm and,
223 secondly, on the extent to which they identify with the social group to which it applies^{98,99}. That
224 participants did not recall moral information is less surprising if they recognized that the creation
225 stories did not describe their own society’s origins or rules of accepted behavior.

226

227 **Narrative structural features may aid transmission.** To the best of our knowledge, no existing
228 theory addresses why particular counterintuitive domains should be recalled more frequently than
229 others. However, our data demonstrate that biologically counterintuitive information was
230 significantly more likely to be transmitted. This result may not necessarily be due to biased
231 content *per se*, but rather could be a consequence of narrative construction. Many of the
232 biological counterintuitive propositions in our stories were repetitive in structure (for example, in
233 the “Muki” story, spiders were transformed into other animals four times in sequence), and
234 recollection may be affected by what Jakobson¹⁰⁰ called the “poetic function” of language¹⁰¹, or
235 the artistic quality of the message itself. In our study design, we credit a causal role to linguistic
236 factors in social learning through our use of accent-based prestige; however, narrative theory
237 itself remains a rich and largely untapped resource in cultural evolutionary accounts of
238 information transmission¹⁰².

239 For stories to be impactful, the content must engage the audience^{103–105} and compete for
240 space in working memory^{106–109}. To this end, stories (and their tellers) employ a suite of features
241 to enhance their salience, including elements that evoke emotional arousal^{110–113} and the use of
242 familiar narrative devices such as rich encoding and repetition^{114,115}. As such, multiple factors
243 influence the success of story transmission and the data demonstrate that transmission biases
244 alone do not capture the full variation.

245
246 **Implications for the understanding of transmission.** The overall fit of our model is high
247 ($R^2_{GLMMc} = 0.524$), but fixed effects only explain a small portion of the variation in recall ($R^2_{GLMMm} =$
248 0.106). One possible explanation for this result is that some as-yet unidentified biases exist in the
249 characteristics of the models or in the content of the stories, and this drives the variation in
250 proposition transmission. However, our methodological approach included every type of content
251 bias supported in the literature, and we could not test the remaining well-documented context
252 biases, such as conformity bias¹¹⁶ and success bias¹¹⁷, because they do not apply to the one-to-
253 one transmission context of our experiment. In the future, if additional content biases are
254 identified in the literature, it would be possible for researchers to re-code our data (see
255 Repository) to test them.

256 Instead, the substantial explanatory power of the random effects in our models may
257 represent the noise of individual variation. The trade-off for gaining real-world experimental
258 validity is typically a greater amount of noise due to uncontrolled circumstances. Our
259 methodological approach did not allow us to control the testing environments, including levels of
260 distraction, participants’ levels of attention, or participants’ personal short and long-term histories.
261 In this way, the experiment mimics real-world cultural transmission, which tends to be filled with
262 random noise that can lead to low fidelity in one-off transmission events^{118,119}. Much debate exists
263 regarding the degree of transmission fidelity required for cumulative culture. Some argue that
264 high-fidelity transmission is required^{120–124}, while others counter that low-fidelity transmission is
265 sufficient^{125–131} and that weak biases can be amplified over repeated rounds of transmission to
266 create strong universal patterns^{119,132,133}. We found that participants’ responses to identical stimuli
267 varied significantly, and transmission fidelity was often low compared to previous studies²⁰.
268 Participants knew they would need to retain and recite the information, but on average they
269 recalled only 14.3% of the propositions presented ($SD = 10.4\%$). In the context of a single-shot
270 experimental transmission event, however, participants have no real incentive to retain
271 information, and these stories were intentionally of considerable length and posed a substantial
272 challenge for working memory. Furthermore, repeated exposure to a story increases
273 comprehension¹³⁴, and narratives that particularly define a group—such as creation stories—are
274 often told multiple times¹³⁵ or are collaborative, with opportunities for audience engagement that
275 allow group members to transform and take ownership of the narrative^{136,137}. Future work, both

276 theoretical and empirical, should consider how models of transmission processes can accurately
277 incorporate individual variation in cultural transmission and responses to content.

278 Our methodological and analytical framework provides a template for future tests of the
279 simultaneous effects of context and content biases. We have performed an experimental test of
280 the relative effects of multiple types of cultural transmission biases presented within a realistic
281 package of narrative information, while incorporating linguistic factors that have been
282 underutilized in the cultural evolution literature. Although we found that prestige was the least
283 important transmission bias, it was still a significant factor in participants' choices of what
284 information to retain and recall, especially for information lacking any internal biases. Our results
285 suggest that the prominent role of prestige-biased transmission models in cultural evolution
286 studies should be scrutinized more heavily and qualified by the presence or absence of other
287 biases, which may have stronger effects under certain conditions. The experimental framework
288 presented here sets the stage for future research to test longstanding questions in cultural
289 evolution, such as: which biases are necessary or sufficient for the development of cumulative
290 culture¹²⁰, which conditions cause learners to favor one type of bias over another⁸³, whether and
291 how the effects of different biases differ cross-culturally^{118,138-140}, how micro-level transmission
292 processes lead to macro-level cultural change^{20,141}, and how we can identify the bias or biases
293 responsible for a *post hoc* distribution of traits¹⁴². The results of this study go beyond academic
294 discourse in cultural evolution to impact other disciplines that rely on the theory and application of
295 communication as a means of disseminating information and motivating behavior change,
296 including education, marketing, conservation, public health, and political science. Storytelling
297 persists as a powerful and enduring tool, dense in cultural information, and utilized across the
298 world to share knowledge and shape the diversity of human culture.

299
300

301 **Methods**

302

303 **Story production.** We selected creation stories, which often pertain to the origins of life, death,
304 nature, and human society, as the narrative form to be used for this study because they are rich
305 in the types of content proposed to be relevant to cultural transmission. Further, creation stories
306 are a familiar pattern cross-culturally for the transmission of knowledge, values, and meaning,
307 and have each individually been subject to many generations of transmission and transformation.

308 We undertook a survey of creation stories using ethnographic data from the electronic
309 Human Relations Area Files (eHRAF) World Cultures database¹⁴³. We conducted the survey by
310 searching for "creation" (and its derivatives) or "origin" within texts indexed under the "mythology"
311 subject code (#773). We performed the search in the Probability Sample Files (PSF) subset,
312 which is a stratified random sample of 60 cultures, each representative of a different "culture
313 area." Our search returned 100 story extracts from 35 cultures, and from this we selected 4 texts
314 for analysis on the basis of appropriate length (~300-800 words) and being written and shared by
315 in-group authors (rather than foreign ethnographers). The stories selected belonged to the A-chik
316 Mande (referred to in eHRAF as "Garo"), Baganda ("Ganda"), Kainai ("Blackfoot"), and Kanaka
317 Maoli ("Hawaiian") peoples. We also included the Genesis creation story (from the ancient
318 Israelites), as presented in the New Revised Standard Version Bible¹⁴⁴, Gen. 1.1-2.3. We coded the
319 resulting 5 ethnographic creation stories at the level of propositions (word clusters consisting of "a
320 predicate plus a series of ordered arguments"²⁰) for the presence of social, survival, emotional,
321 moral, rational, and counterintuitive content biases. Definitions of these biases as used for coding
322 are listed in the Supplementary Information (Supplementary Table 6). We carried out
323 propositional analysis under the protocol established by Turner and Greene¹⁴⁵.

324 For the experiments, we commissioned two written artificial creation stories (see
325 Acknowledgements). We did this rather than using the ethnographic stories we sampled in order

326 to avoid issues of cultural appropriation surrounding the use of stories from real societies, and to
327 ensure that our participants would all be equally unfamiliar with the stories. We recognize that
328 stories artificially created to satisfy controls have not naturally evolved through cultural
329 transmission, however, this confound cannot be removed from experimental work requiring
330 comparable stimulus material. To minimize this effect, a professional author wrote the stories,
331 and we aimed to preserve narrative flow in subsequent story revisions. The first story, “Muki,”
332 explains how the actions of a child abandoned by its parents shaped a rugged landscape and its
333 varieties of life-forms. The second story, “Taka & Toro,” describes two jealous seafaring siblings
334 and their competition over the friendship of the people they created. Over many iterations, we
335 edited the texts of these artificial creation stories at sentence- and then proposition-level to
336 ensure the proportions of each type of biased proposition in each story matched one another, and
337 also fell within 90% confidence intervals of the proportions seen in the coded ethnographic
338 creation stories (Supplementary Table 7). We tuned both stories to be approximately 850 words
339 (Muki 887, Taka & Toro 835) and 270 propositions (Muki 265, Taka & Toro 273) to avoid ceiling
340 effects for recall and to be of roughly equal complexity. Readability scores (based on number of
341 syllables per word and sentence structure) for these artificial stories were roughly equivalent and
342 used simpler language than the ethnographic stories they were modeled after (Flesch-Kincaid
343 grade level: Muki 4.91, Taka & Toro 5.03, Ethnographic Mean 8.22 [90% CI: 6.42, 10.02]; Flesch
344 reading ease: Muki 84.5, Taka & Toro 81.9, Ethnographic Mean 71.24 [90% CI: 62.24, 80.24]).
345 The final versions of the two artificial creation stories, along with lists of their propositions and
346 coded biases, can be found in the Repository.

347
348 **Recordings.** We used language accent to index prestige, in line with findings from
349 sociolinguistics^{63,66,146–148}. Language attitude studies have demonstrated that non-localized
350 “standard” accents are associated with high prestige^{149–152} based on ideological values^{65,153},
351 although regional non-standard accents demonstrate differential prestige^{63–65,154}. We recorded
352 self-identified middle-aged white male speakers with high- and low-prestige accents calibrated for
353 the participants’ locations telling the two stories (“Muki” and “Taka & Toro”). We selected the high-
354 and low-prestige accents based on the results of a previous study⁶⁷. For both the UK and USA
355 participants, Received Pronunciation (“RP”) was the high-prestige accent. For the UK sample, the
356 low-prestige accent was West Country, from South West England; and for the US sample, the
357 low-prestige accent was Inland South, spanning the southern Appalachian, Ozark, and Ouachita
358 mountain ranges. We standardized the recordings for volume and length (each 5 min, 19 s).

359 For an independent assessment of accent prestige, we also recorded our speakers
360 reading the first paragraph of the *Comma Gets a Cure* passage (see Acknowledgements). This
361 passage contains words from Wells’s lexical set, designed to highlight phonological variation
362 between different accents of English¹⁵⁵. We presented these recordings (range 35 s to 39 s) to
363 participants to confirm that their perceptions of the prestige of each speaker matched what was
364 expected (see Experimental protocol, below).

365
366 **Participants.** We recruited UK participants on the Prolific Academic platform ($n = 96$), and US
367 participants on Amazon Mechanical Turk ($n = 100$) using TurkPrime¹⁵⁶. Participants were eligible
368 to take part in this study if they: had not taken part in any previous studies by the researchers;
369 had taken part in and had successfully completed over 95% of at least 100 studies on Prolific
370 Academic or over 98% of at least 5,000 tasks on Amazon Mechanical Turk; and were native
371 English speakers. We excluded data from 33 participants due to technical recording errors or
372 external interference (e.g. a second person contributing to the recall of a story).

373
374 **Experimental protocol.** The experiment was administered through a custom web browser
375 application using the SurveyJS library (source code available at:

376 <https://github.com/seannyD/StoryTransmission>). Participants were directed from their respective
377 recruitment platforms to the web application on University of Bristol servers. Participants first
378 selected their location, which determined which of the locally-calibrated accent recordings they
379 would hear. Participants were instructed to listen once (due to expected completion rates) to a
380 recording of the first artificial creation story and were told that they would be asked to recall the
381 story in as much detail as possible.

382 After listening to a creation story, participants took part in a working memory distraction
383 task based on the Visual Spatial Learning Test¹⁵⁷. This task involved playing three rounds of a
384 game in which participants had to recall symbols and their positions on a grid. For the symbols,
385 we used the 9 most dissimilar characters from the “BACS-1” artificial character set¹⁵⁸. This
386 distraction task took approximately 5 minutes to complete and also provided a measure of
387 unbiased working memory, which we calculated as the number of cards placed on the grid that
388 matched the positions displayed (regardless of the symbol), plus the number of cards placed on
389 the grid that matched both the positions and symbols displayed, averaged across all trials
390 (equivalent to the Position Learning Index, or “PLI” score, of ¹⁵⁷).

391 Once this task had been completed, participants recorded their oral recollection of the
392 creation story. They were given the opportunity to pause and continue recording, but were not
393 allowed to return or re-record after advancing to the next task. This process, including the working
394 memory distraction task, was then repeated for the second story and with the accent of opposite
395 prestige level. Story order and accent were both randomized for presentation in the experiment.
396 Each participant heard “Muki” in one accent condition and “Taka & Toro” in the alternate accent
397 condition.

398 After recording their recollections of both stories, participants listened to recordings of the
399 *Comma Gets a Cure* passage read by the speakers providing the stories. To test that the different
400 accents consistently indexed the expected differences in prestige, participants rated the speakers
401 using the items for the Position-Reputation-Information (PRI) scale of individual prestige⁵⁶ as well
402 as additional solidarity and dynamism domains⁶⁶. Finally, participants completed a demographic
403 questionnaire including participants’ residence history and self-reported accents of English. We
404 collected data pertaining to gender and ethnicity in line with ethical practices in research and
405 guidelines from national statistical agencies.

406
407 **Data coding and transcription.** We transcribed the audio files containing participants’ story
408 recordings, and coded each for the presence or absence of each proposition from the original
409 texts (see Repository for coding protocols, transcripts and coded data). Because we instructed
410 participants that they did not need to recall the stories verbatim, we counted the presence of a
411 proposition if the meaning remained consistent through different word choices or constructions
412 (e.g. we accepted synonyms and did not penalize the order of recall). If an error in the retellings
413 was carried forward in the story, we only marked it absent in the first instance. We only counted
414 biased propositions as present if the retelling retained the biased element (e.g. social interaction,
415 counterintuitive properties, etc.).

416 To assess intercoder reliability, a second researcher re-coded a subset of 33 recordings
417 (representing approximately 10% of the sample). We found substantial agreement between the
418 coders (Cohen’s $\kappa = 0.737$, $p < 0.01$), and coders discussed any disagreements until reaching
419 consensus on the final coded data.

420
421 **Data analysis.** We used a set of generalized linear mixed models (GLMMs) to model the
422 presence or absence of a particular proposition. Here, we tested the effects of eight different
423 transmission biases by fitting a set of 58 candidate models that account for the potential effects of
424 these biases in isolation and in combination with one another (Supplementary Table 3). For these
425 models, the fixed effects we examined can be broken down into three categories of: 1) *story-*

426 *based effects* (story, presentation order, and line number representing position in the story and
427 quadratic line number representing primacy or recency effects); 2) *transmission biases* (prestige,
428 social, survival, positive emotional, negative emotional, moral, rational, and counterintuitive
429 domain); and 3) *demographic effects* (country, gender, ethnicity, accent matching low-prestige
430 speaker, childhood town size, childhood town matching region of low-prestige speaker,
431 education, occupation, income, and working memory score). Age was excluded from the
432 demographic variables because of a lack of any predictive theory for its effects on recall beyond
433 those of working memory. We also included random effects for participant and proposition
434 number in all models to capture the remaining variance from these sources. Variable descriptions
435 and the full data set are available in the Repository.

436 After model fitting, we compared models on the basis of each model's Akaike information
437 criterion (AIC) score. Due to the lack of a single dominant model with a weight greater than 0.95,
438 we averaged the parameters of all models according to their Akaike weights¹⁵⁹. As our main
439 interest was in determining which factors had the strongest effects¹⁶⁰, we determined full model-
440 averaged parameter estimates using the "zero method"^{159,161}. This substitutes a value of zero for
441 parameter estimates and errors in models where the parameter does not appear and computes a
442 weighted average for each parameter using the models' Akaike weights.

443 We re-fit the full set of models using a continuous measure of the participants'
444 perceptions of the speaker's prestige—as factor scores from the PRI scale of individual
445 prestige⁵⁶—rather than the binary high-low prestige variable, for the subset of participants that
446 provided this information (roughly two thirds of the full data set). Results were qualitatively similar;
447 however, direct comparisons cannot be made due to these analyses being performed on a
448 nonrandom subset of the data.

449 We used the R statistical environment, versions 3.5.1 (2018-07-02) and 3.6.1 (2019-07-
450 05), for all analyses¹⁶².

451
452 **Ethics statement.** Prior approval for research protocols was obtained from the Colorado State
453 University Institutional Review Board (protocol #014-16H) and the University of Bristol Faculty of
454 Arts Human Research Ethics Committee (protocols #26561, #31041, and #38323). We obtained
455 prior informed consent from all participants (full text of the consent form available at:
456 [https://github.com/seannyD/StoryTransmission/blob/master/www/StoryTransmission/survey/SUR](https://github.com/seannyD/StoryTransmission/blob/master/www/StoryTransmission/survey/SURVEY_consent.js)
457 [VEY_consent.js](https://github.com/seannyD/StoryTransmission/blob/master/www/StoryTransmission/survey/SURVEY_consent.js)). We compensated all participants for their time at rates above local minimum
458 wages based upon the time taken to complete the tasks.

459 Participant data were gathered via a website hosted by the University of Bristol. A
460 HyperText Transfer Protocol Secure (HTTPS) site was used to send data via an encrypted
461 Transport Security Layer (TSL) to a University of Bristol virtual server that could only be accessed
462 by the research team. Participants were assigned a random unique ID and no directly identifying
463 information was gathered from participants. Amazon Mechanical Turk Worker IDs were encrypted
464 and anonymized through TurkPrime to prevent identifiability. Voice recordings were securely
465 stored in memory on the client side before being compressed and transferred to the virtual server
466 via the encrypted TSL. Data were downloaded from the server to the local computers of the
467 researchers for analysis via encrypted Secure Copy Protocol (SCP).

468
469 **Data availability.** All data and R scripts used for analysis will be deposited in a public repository
470 prior to publication.

471
472

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474

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481 *Comma Gets a Cure* is copyright 2000 Douglas N. Honorof, Jill McCullough & Barbara
482 Somerville, text available online at: <https://www.dialectsarchive.com/comma-gets-a-cure>.
483 Color palettes used in figures are derived from a technical note by Paul Tol (available at:
484 <https://personal.sron.nl/~pault/data/colourschemes.pdf>) and are optimized for color-blind readers.
485
486

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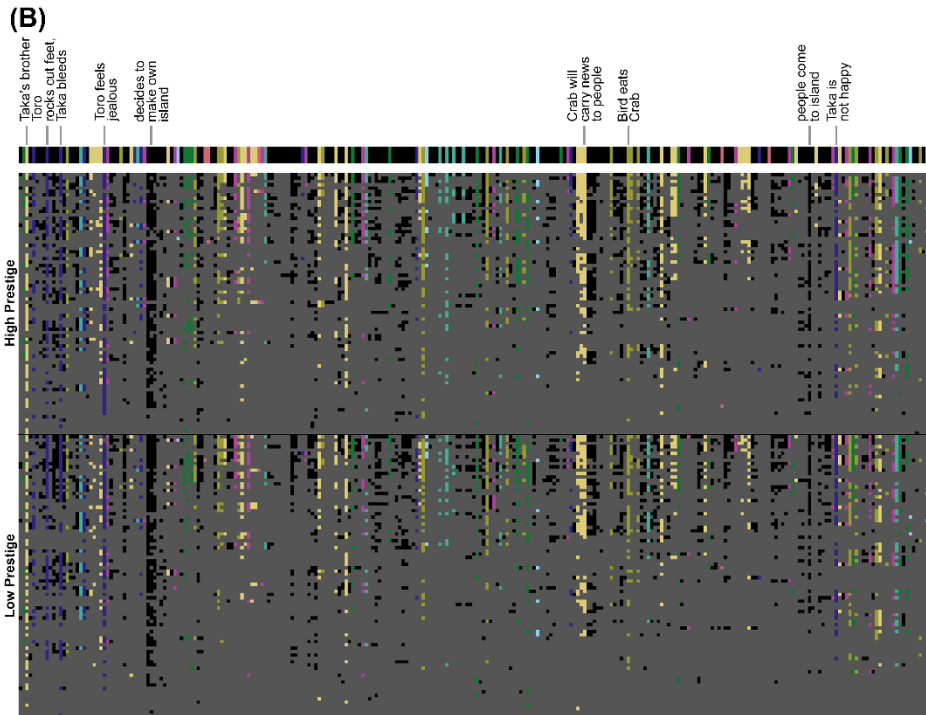
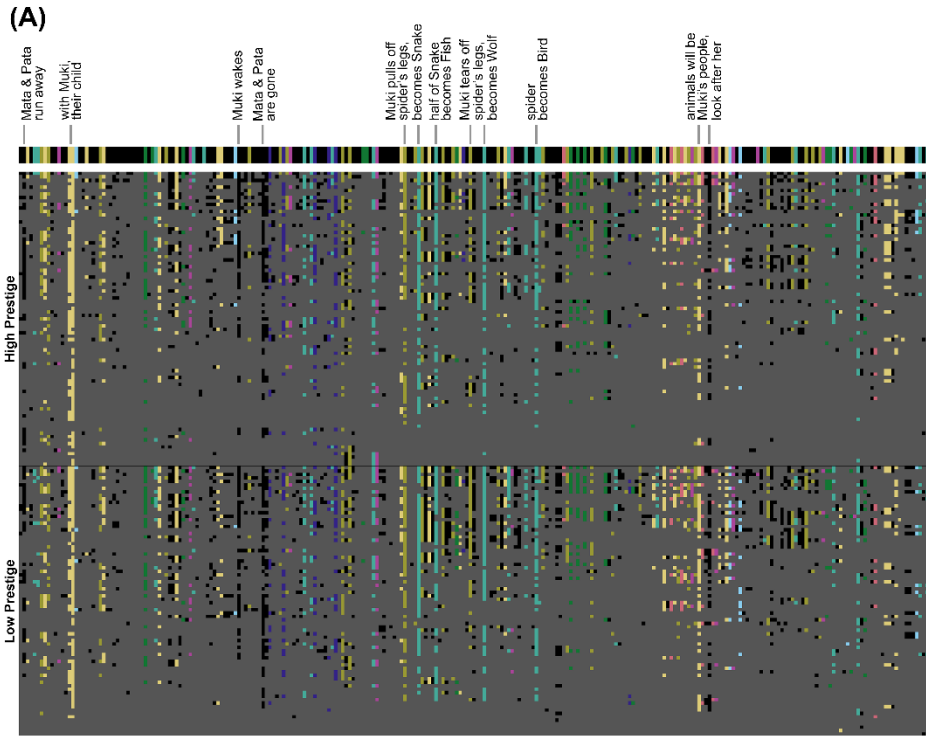
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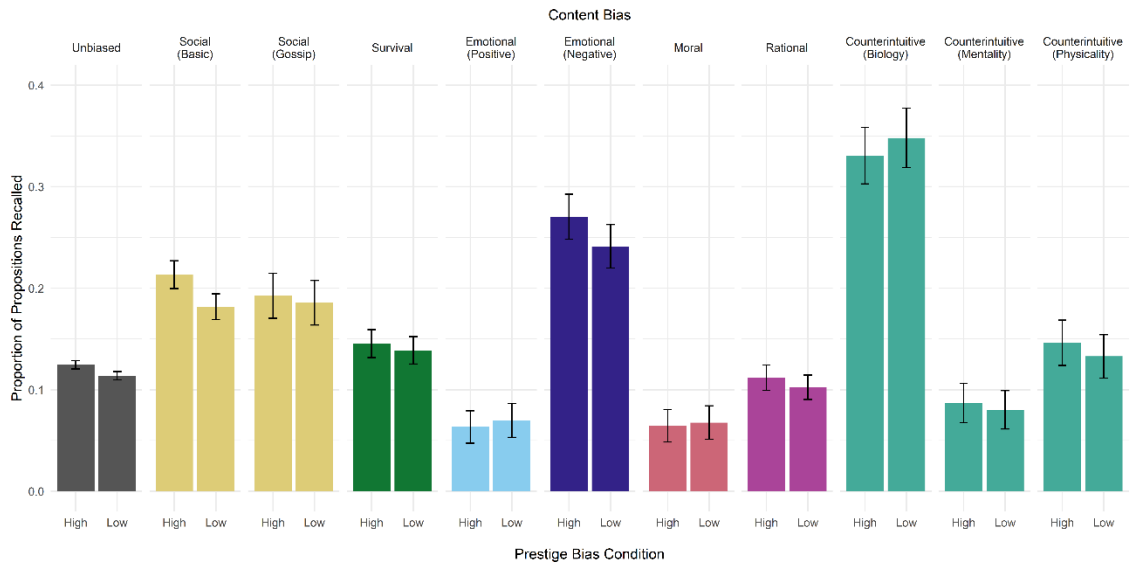
Figures



Content Biases: Social Survival Emotional + Emotional - Moral Rational Counterintuitive Multiple Unbiased

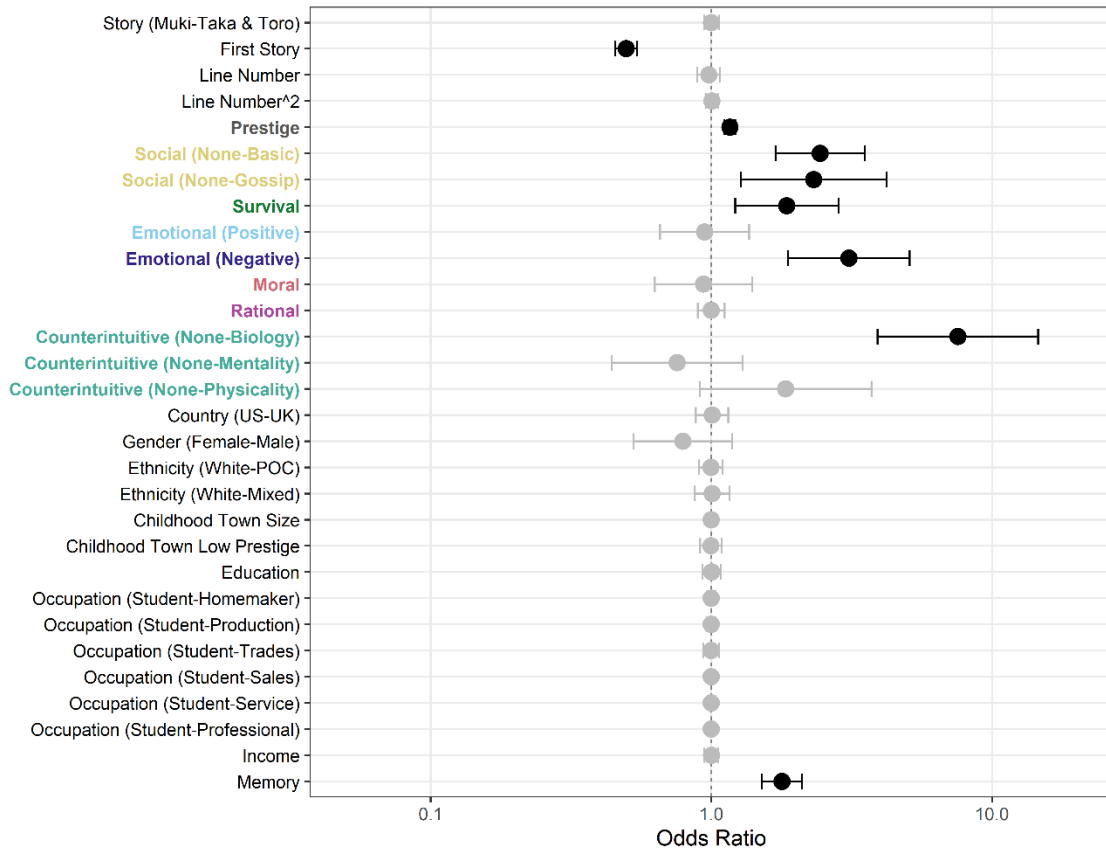
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Fig. 1. Color matrices of the presence or absence of propositions in recalled stories. Each row represents one participant's recall ($n = 165$ per panel), sorted by hierarchical clustering for visibility. Each column is a proposition from the Muki (A) or Taka & Toro (B) artificial creation stories, from left to right in the order in which the propositions appeared in the stories. The thick line above each panel shows the full set of propositions contained in the story as originally told, with labels indicating propositions with exceptionally high recall (using Tukey's definition of outliers). Within each panel, rows in the upper portion were read by a high-prestige speaker, while rows in the lower portion were read by a low-prestige speaker. Dark gray propositions were not recalled (absent). Recalled propositions (present) are each represented by a color that indicates the content biases they contained, as indicated at the bottom of the figure: *social* information is yellow, *survival* is green, *positive emotional* is light blue, *negative emotional* is dark purple, *moral* is pink, *rational* is magenta, *counterintuitive* is teal, and propositions containing more than one bias are gold. Unbiased propositions, those that did not contain any biased information, are shown as black.



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Fig. 2. Mean proportion of propositions recalled from artificial creation stories by type of content bias and by speaker prestige. Error bars represent 95% confidence intervals. Propositions containing more than one type of content bias are excluded (N = 10,864 propositions recalled / 78,965 presented).



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Fig. 3. Forest plot of odds ratios from full model-averaged coefficients for fixed effects. Odds ratios and 95% confidence intervals are depicted such that variables for which confidence intervals do not overlap with 1 have a significant positive (above 1) or negative (below 1) effect on proposition recall (black), compared to variables that did not have a significant effect (gray). Binary and categorical variables are represented relative to the reference level (false/not present unless specified otherwise). For ordinal variables (childhood town size, education, and income), only linear contrasts are shown.