Prestige and dominance based hierarchies exist in naturally occurring human groups, but are unrelated to task-specific knowledge

Brand, CO[1,2] and Mesoudi, A[1]

[1]Human Behaviour and Cultural Evolution Group, Department of Biosciences, College of Life and Environmental Sciences, University of Exeter Cornwall Campus, United Kingdom.

[2]Corresponding author, C.Brand@exeter.ac.uk

*Pre-registered on the Open Science Framework at https://osf.io/tasu5/

Word count (main text): 6,464

Word count (everything): 7,417

5 figures, 3 tables

ABSTRACT

Prestige and dominance are thought to be two evolutionarily distinct routes to gaining status and influence in human social hierarchies. Prestige is attained by having specialist knowledge or skills that others wish to learn, whereas dominant individuals use threat or fear to gain influence over others. Previous studies with groups of unacquainted students have found prestige and dominance to be two independent avenues of gaining influence within groups. We tested whether this result extends to naturally-occurring social groups. We ran an experiment with 30 groups of 5 people from Cornwall, UK (n=150). Participants answered general knowledge questions individually and as a group, and subsequently nominated a team representative to answer bonus questions to win money on behalf of the team. Participants then rated all other team-mates anonymously on scales of prestige, dominance, likeability and influence on the task. Using a model comparison approach with Bayesian multi-level models, we found that prestige and dominance ratings were predicted by influence ratings on the task, replicating previous studies. However, prestige and dominance ratings did not predict who was nominated as group representative. Instead, participants nominated team members with the highest individual quiz scores, despite this information being unavailable to them. Interestingly, team members who were initially rated as being high status in the group, such as a team captain or group administrator, had higher ratings of both dominance and prestige than other group members. In contrast, those who were initially rated as someone from whom group members would like to learn had higher prestige ratings, but not higher dominance ratings, supporting the claim that prestige reflects social learning opportunities. Our results suggest that prestige and dominance hierarchies do become established in naturally occurring human social groups, but that these hierarchies may be more domain-specific and less flexible than we anticipated.

KEYWORDS: cultural evolution, dominance, prestige, social hierarchy, social learning

INTRODUCTION

Prestige and dominance are said to be 'two ways to the top' in gaining status and influence in human social groups (Cheng, Tracy, Foulsham, Kingstone, & Henrich, 2013), and represent two evolutionarily distinct psychological processes found in our species (Henrich & Gil-White 2001). In contrast to non-human animals, in which dominance-based hierarchies prevail, Henrich and Gil-White (2001) argued that human hierarchies are additionally prestige-based. Prestige is attained by individuals who are particularly skilled or knowledgeable in a certain domain. Other individuals in the group confer deference on the prestigious individual in order to gain access and proximity to them for social learning opportunities (Henrich & Gil-White, 2001). Over time, prestigious individuals gain status, respect, admiration, and attention from other group members. In contrast, dominant individuals gain status and influence over other group members using fear, threat or intimidation. This coercion-based form of influence is common across social species, including humans, while Henrich and Gil-White (2001) argued that prestige is unique to humans due to our unusually extensive reliance on social learning.

The prestige-dominance distinction has received much attention across social psychology and evolutionary anthropology since its introduction (for reviews see Maner & Case 2016; Cheng et al. 2014), and has stimulated empirical tests of the many predictions put forth by Henrich & Gil-White (2001). Atkisson et al. (2012) found that participants in a virtual artifact-design experiment chose to view and copy the artifacts of other group members who had been viewed the most by all other group members. This occurred despite these 'viewing time' attentional cues

being fictional, illustrating the potency of prestige-related cues in human social learning. Similarly, Chudek et al. (2012) found that children copied the food and object choices of adults who had been watched by bystanders, compared to unwatched adults. In a second experiment, Chudek et al. found provisional evidence that prestige bias is domain sensitive by showing that children copy the object choices, but not the food choices, of adults previously shown using objects but not food (and the reverse for adults shown initially choosing food).

While these studies demonstrate that adults and children use prestige cues (e.g. being attended to by third parties) as guides for choosing from whom to learn, other studies have explicitly compared prestige and dominance as distinct means of attaining status. Cheng et al. (2010) developed and validated a scale of traits that map strongly onto either prestige or dominance, but not both. Cheng et al.'s prestige scale includes items such as "members of your group respect and admire him/her", and "his/her unique talents and abilities are recognized by others in the group." In contrast, the dominance scale includes items such as "he/she enjoys having control over other members of the group," and "he/she is willing to use aggressive tactics to get his/her own way." These combinations of traits have been found to constitute two distinct and viable ways of attaining status and influence over a group (Cheng et al., 2013). Cheng and colleagues (2013) had previously unacquainted, same-sex student groups complete a decision-making task to rate various items, such as rope, matches and parachutes, in order of importance for use on the moon. Participants rated items individually, then jointly as a group following group discussions, then rated every other group member on prestige and

dominance using the aforementioned scales. Prestige and dominance ratings were found to independently predict (i) participants' influence in the task as rated by other group members; (ii) participants' influence in the task as rated by external observers via videotape; and (iii) a behavioural measure of participant influence, specifically the degree to which that participant's individual decision matched the eventual post-discussion group decision. Analyses of the external observers' gaze direction whilst watching the video footage revealed that individuals with high dominance or prestige ratings also received more visual attention than those with low dominance or prestige ratings.

Our aim here is to extend and verify the findings reviewed above concerning the viability of prestige and dominance as strategies for attaining status within groups. We repeated Cheng et al.'s (2013) general design in which participants in groups complete a task and rate each other on prestige and dominance using the same scales used by Cheng et al. (2010) and Cheng et al. (2013). We made two major modifications designed to explore the generality of Cheng et al.'s findings.

First, rather than use groups of unacquainted university students brought together for the sole purpose of an experiment (as in Cheng et al. 2013), we instead recruited already-established community groups of various ages and backgrounds. These included sports clubs, volunteer groups, businesses, bands and chess clubs. This allowed us to test whether dominance and prestige hierarchies are evident in already-established groups of non-students, and whether prestige and dominance affect decisions within groups who have naturally developed relationships over time.

We feel this is an important question because it is rarely the case in reality that individuals make decisions in groups of strangers with whom they may never interact again. Furthermore, our groups also featured a range of ages, social backgrounds and gender compositions, making them more representative of the general population than the same-sex groups of university students used in previous studies (Cheng et al. 2010, 2013), and following recommendations to use broader samples in psychological research (Henrich, Heine & Norenzayan 2010).

Second, we wanted to test the key prediction of Henrich and Gil-White (2001) that prestige is tied to knowledge, while dominance is not. This prediction stems from the assumption that prestige functions to aid individuals in identifying potential demonstrators from whom to learn valuable skills and knowledge. If this is the case, it follows that prestigious individuals should also be more knowledgeable or skilful. Dominant individuals, in contrast, attain their dominance via physical or verbal coercion and threat, and so dominance should be unrelated to knowledge. Cheng et al. (2013) compared prestige and dominance, but in a task – choosing items to use on the moon – which was not clearly related to a participant's prior or general knowledge. While there were 'correct' answers on the moon task, these were unlikely to depend on participants' past knowledge of moon landings. We therefore used a general knowledge quiz, with a series of multiple-choice questions each of which had a definite correct and incorrect answer, and which relied on participants' existing general knowledge. 'Success' is now the number of correct answers on this task, which is independent of other group members' answers. We also had group members anonymously vote for a single group member to complete a bonus round

144 of quiz questions, with the highest scoring representative winning money for their
145 group. This created an incentive for participants to identify and vote for the most
146 knowledgeable, and therefore most prestigious, group member.
147
148 *Predictions*
149 All of our predictions were pre-registered and are available at the OSF link
150 https://osf.io/tasu5/. We recruited 30 groups of mixed-sex, adult participants from
151 already-established community groups across Cornwall, UK to complete our quiz
152 task. Before the task, we sought to validate the prestige and dominance scales
153 created by Cheng et al. (2010) by asking participants to choose an influential
154 member of their wider community or country and rate their chosen person on these
155 scales. Based on the results of Cheng et al. (2010, 2013) that prestige and
156 dominance are independent means of acquiring status, we made the following
157 prediction:
158
159 H1: Individuals viewed as having high status in the wider community or country
160 are rated as either highly prestigious or highly dominant, but not both.
161
162 In order to test Henrich and Gil-White's (2001) assertion that prestige functions to
163 identify targets of social learning, we then asked participants to choose a member
164 of their wider community or country from whom they would like to learn a particular
165 skill, or learn to be like. We made the following prediction:
166

H2: Individuals rate those from whom they want to learn in the wider community or country as having high prestige, but not high dominance.

Participants then completed the quiz, first individually and then in their groups. During the group stage, participants were told that they had to discuss and agree on every answer, rather than divide the quiz into sections per person, or by voting on each question. After handing in the group answers, each group member then anonymously voted for one other member of their group (excluding themselves) to take part in a bonus quiz on the group's behalf. Before the nominee was revealed, each participant rated each other member of their group for influence, prestige, dominance and likeability. The nominee then completed the bonus round of questions alone.

Following Cheng et al.'s finding that influential group members are either prestigious or dominant, but not both, we predicted that:

H3: Individuals who are rated as highly influential in the group task are also rated as highly prestigious or dominant, but not both.

Given that more knowledgeable individuals should score higher on our quiz, and knowledgeable individuals should be prestigious (but not dominant) (Henrich & Gil-White 2001), we further predicted that:

H4: Individual score on the quiz predicts prestige but not dominance ratings.

We also tested two predictions stemming from prior work relating to other traits differentially associated with prestige and dominance, but with our acquainted, naturally-occurring groups. Given previous findings that prestigious, but not dominant, individuals are liked more (Cheng et al. 2013), we predicted that:

H5: Ratings of high prestige predict likeability but high dominance ratings do not.

We also predicted that overconfidence would be related to dominance, given previous findings that dominance is related to hubristic rather than authentic pride (Cheng et al. 2010). We measured overconfidence by asking each participant to estimate their score on the individual section of the quiz. Hence:

H6: Overconfidence predicts ratings of high dominance but not prestige, whereas accurate confidence or under-confidence predicts prestige.

Finally, we made a prediction related to the nomination of one group member to represent the group in the bonus round. Given that participants knew that more-knowledgeable group members were more likely to win prize money for their group during the bonus round, and the aforementioned link between knowledge and prestige, we therefore predicted that they should nominate prestigious individuals, hence:

H7: Individuals who are rated as highly prestigious (rather than highly dominant) are nominated to represent the group.

METHODS

All methods and predictions, along with analysis plans, were pre-registered and are available to view on the Open Science Framework at https://osf.io/tasu5/

Participants

32 groups of 5 participants from local, already established community groups were recruited. These included sports clubs, volunteer groups, businesses, bands, chess clubs, etc. For a full list of participating groups see supplementary material. Each group had exactly 5 individuals to control levels of individual influence within each group and allow robust comparison across groups. Groups were recruited between June 2017 – February 2018. Two of the 32 groups' data were removed for the following reasons. One group (Group number 1) was a pilot test consisting of fellow office mates who may have been knowledgeable of our hypotheses. Another group (Group number 11) was not used as an elderly participant left the study halfway through due to concentration problems, leaving the remaining group with only 4 participants. As we wanted every group to have exactly 5 participants, we allowed the group to take part in the rest of the task, but only used their wider-community ratings, and not their within-group ratings. Our participants include 82 females and 54 males (not all participants disclosed their gender), with mean age of 46.49 (sd: 21.51).

Materials

We used the prestige and dominance scales from Cheng et al. (2013) available at http://ubc-emotionlab.ca/research-tools/dominance-prestige-scales/, as well as the

measures of “influence” and “likeability” used in Cheng et al.’s (2013) study. All measures are reproduced in our supplementary material.

Our focal task was a general knowledge quiz consisting of 40 alternative choice questions from four categories of 10 questions. Four questions from each category were paired with a picture, the rest were exclusively text-based. The categories were “Geography”, “Weight estimation”, “Language identification”, and “Art history”. An example question for the weight estimation category is “How much does a camel weigh?” a) 48kg b) 480kg. An example question from the language identification category is “The word “pisică” means ‘cat’ in which language? a) Romanian b) Hungarian. The four topics were chosen to represent different domains of knowledge that are not necessarily linked to academic ability or education, but may reflect experiences related to the particular domains. For example, an individual may not be particularly educated in mathematics, but may be skilled at estimating weights of various objects due to the nature of their work/hobbies. The 40 questions are a subset of a 100 question quiz used for an online study by the authors. The initial 100 questions were chosen by using a freely available database of 15000 trivia questions, and were adapted to be multiple choice answers and to fit into the four topics described. These 40 questions were chosen to encompass the hardest and easiest questions from each topic after piloting online. The mean individual score of our 150 participants was 28.625 (3.858). The quiz is available in supplementary material.

Procedure

Participants were given an information sheet and asked to sign their consent before taking part. The experiment was granted ethical approval by the University of Exeter Biosciences ethics committee. Participants were first given stickers with unique ID numbers so that participants never referred to each other by name during the ratings, and ratings were anonymous to each other as well as to the experimenter. They then completed the following activities:

1) *Wider Community Ratings:* Participants were individually asked to name a person either from their local community (e.g. doctor or councillor) or country (e.g. prime minister/celebrity) who they think has high status/influence over their community or country. Participants then rated this person using the prestige and dominance scales. Participants were then asked to name someone either from their local community or country who they would like to "learn from", or "learn to be like", and then rated this person using the prestige and dominance scales.

2) *Initial within-group ratings:* Participants anonymously named another group member (using the ID numbers provided) who they deem to have "high status or influence" over the group, e.g. a teacher, tutor, team captain or group administrator. Participants were then asked to name an individual from their group (using the ID numbers) who they would most like to "learn from" or "learn to be like," (e.g. the best rower/chess player). Participants were told

that if no individual group member immediately comes to mind or fits the criteria then to leave those questions blank.

3) *Individual Quiz:* Participants were then asked to complete the 40 item quiz individually without consulting each other or discussing the questions. After they finished, participants were asked to provide their estimated score on the quiz (i.e. how many questions they answered correctly out of 40) at the bottom of the answer sheet. Participants then handed in their answer sheet marked with their individual ID number.

4) *Team Quiz:* Participants then had ten minutes to complete the same 40 question quiz as a group. Participants were told that the highest scoring group will be given a prize of £500. Participants were told that they had to discuss and agree on every answer, rather than divide the quiz into sections per person, or by voting on each question. The experimenter (COB) told each group that she did not want to affect their decisions or interactions, and so separated herself from the group and wore earphones with loud music playing so as not to be able to hear the group discussion. The experimenter timed the group and let them know when they had 5 minutes remaining, and 2 minutes remaining. The experimenter ensured that no participants used their mobile phones throughout.

5) *Nominations:* After handing in their group answers, participants were asked to anonymously vote for who they would like to be put forward to represent

their group on a bonus round of 8 new questions, two questions from each section. They were informed that the top scoring group on the bonus round would also be rewarded £500. Participants were instructed not to vote for themselves (participants were given voting slips with their own ID so the experimenter could check for this).

6) *Within-group ratings:* After handing in their voting slips, and before the nominee was revealed, participants anonymously rated each of the other group members on the dominance and prestige scale (by using their ID numbers), as well as rating each other group member on how much influence they had on the group decision, and how likeable they were, using the scales used by Cheng et al. (2013). Once participants had finished the rating sheets, the nominated individual was revealed and given the bonus quiz to complete individually. Participants were then debriefed. The winning groups were announced and awarded the prize money in March 2018 after all groups had been tested.

Analyses

We used a model comparison approach with a variety of multi-level models using the *Rethinking* package in R (McElreath, 2016). Full analysis scripts and data are available at www.github.com/lottybrand22/GH_Kernow , and were pre-registered at https://osf.io/tasu5/.

Models were said to be a better fit to the data if their WAIC value held the most weight out of all models tested. Model parameters were said to have an effect on the model outcome if their 89% credible interval did not cross zero. We included model parameters based on a priori hypotheses. See Tables 1, 2 and 3 for model details.

Priors were chosen to be weakly regularising, in order to control for both under and overfitting the model to the data (McElreath, 2016). The robustness of the results were checked by trying a variety of priors, as well as a variety of chains and iterations. Trace plots and effective sample sizes were used to check for appropriate model convergence throughout.

When analyzing the prestige and dominance Likert scale ratings, we used ordinal categorical multi-level models, with varying intercepts for who the rater was (rater ID), who was being rated (rated ID), the group, and Likert scale item. This allowed us to use each Likert scale item as the unit of analysis, rather than average over several items, in accordance with recent recommendations on how to treat Likert scale data (Bürkner & Vuorre, 2018; Liddell & Kruschke, 2017).

When analyzing who was nominated for the bonus round we used a binomial multi-level model with group as a varying intercept. When prestige and dominance ratings were used as predictor variables in the nomination model, the Likert scale ratings for each person were averaged and a proportion of the total scale was calculated for each participant. Thus, if a person was given 7/7 for every item by every rater,

they would have a total proportion of 1, and if a person was given 1/7 for every item by every rater, they would have a total proportion of 0.

Overconfidence was calculated as the participants' estimated score subtracted from their actual score. Thus, any positive value reflects "overconfidence", and a negative value would reflect "underconfidence". This value was also centred and scaled, as were all other predictor variables. In addition, we coded the variable as binary to reflect the prediction that "accurate confidence or underconfidence" would be related to prestige. As "accurate" confidence is only represented by a value of zero (no difference between estimated and achieved score), we coded overconfidence as anything over zero, and everything else as "accurate or underconfidence." This binary measure did not give different results to our continuous measure, so we chose to report our continuous, pre-registered measure in our results section.

Participants were coded as "initially influential" (1 rather than zero) if they were named by at least 3 group members in the initial within-group ratings as someone who is particularly influential to the group (such as team captain or group admin). Participants were coded as "learning models" (1 rather than zero) if they were named by at least 3 group members in the initial within-group ratings as someone from whom they would like to learn from (e.g. learn a skill from or learn to be like). When sex was a predictor in any model, males were coded as zero and females as 1, thus any effect of sex is the effect of being female compared to male.

RESULTS

H1 and H2: Wider community ratings of prestige and dominance

Hypotheses H1 and H2 concerned the participants' prestige and dominance ratings of community figures. H1 was partially supported, in that influential members of the community, such as politicians, activists, or celebrities, were rated as highly prestigious, but not highly dominant (mean (sd) prestige = 4.88 (1.33); dominance = 3.89 (1.45). Contrary to H1, and to Cheng et al. (2013), prestige and dominance ratings for influential community figures were not statistically independent, but instead dominance ratings were negatively predicted by prestige ratings (mean coefficient estimate: -3.22, 89% Confidence Interval: [-3.86, -2.61]). That is, figures who were rated as highly prestigious were rated as low in dominance, and vice versa. For a full list of influential figures who were named, see supplementary material. Cronbach's alpha for both the prestige and the dominance scale was high (prestige: $\alpha = 0.89$; dominance: $\alpha = 0.86$), suggesting there was a high level of internal consistency in the scales.

In support of H2, members of the community from whom participants would like to learn were rated as highly prestigious, but not highly dominant (mean (sd) prestige = 5.77 (0.70); dominance = 2.98 (1.19). Prestige and dominance ratings for learning models in the community were statistically independent, given that prestige ratings did not predict dominance ratings (coefficient estimate: -0.84, 89% CI:[-1.88, 0.14]). For a full list of community members from whom participants would like to learn, and the skills they would like to learn, see supplementary material.

406

407 **H3-H6: Within-group prestige and dominance ratings**

408 To test hypotheses H3-H6, we ran two sets of model comparisons, one with
409 prestige ratings from other group members as the outcome (Fig 1 and Table 1), and
410 the other with dominance ratings from other group members as the outcome (Fig 3
411 and Table 2).

412

413 In accordance with H3, participants were rated as more prestigious if they were also
414 rated as highly influential during the group task (mean coefficient estimate: 0.46,
415 89% CI:[0.36,0.55], see Fig.2). Contrary to H4, however, individual quiz score did
416 not predict high prestige ratings (score: -0.09, CI:[-0.19,0.01]). In accordance with
417 H5, participants were more likely to be rated as highly prestigious if they were also
418 rated as highly likeable (0.67, CI:[0.57,0.77]). Contrary to H6, confidence on the quiz
419 was unrelated to prestige ratings (-0.07, CI:[-0.16,0.02]). (See Fig. 1).

420

421 In addition to our a priori, hypothesis-based prestige model, results from our full
422 model suggested that participants were more likely to be rated as highly prestigious
423 if they were initially named as an influential group member, such as a team captain
424 or group administrator (0.29, 89% CI: [0.05,0.55]). Participants were also rated as
425 more prestigious if they were initially named as someone that others would like to
426 learn from (0.41, CI:[0.11,0.73]). Whether the participant was nominated for the
427 bonus round did not predict prestige ratings, neither did the sex of the participant
428 (nominated: -0.08, CI:[-0.31,0.14], sex: 0.16, CI:[-0.04,0.35]). However, age did

predict prestige ratings, with older participants rated as more prestigious (0.16, CI:[0.03,0.29]). (See Fig.1).

The best fitting model was the full model, suggesting that other parameters were important aside from those in the a priori, hypothesis-based model. An exploratory model was included in addition to the pre-registered models, to see if initial ratings produced a better model fit than the prestige model, however this was not the case (see Table 1).

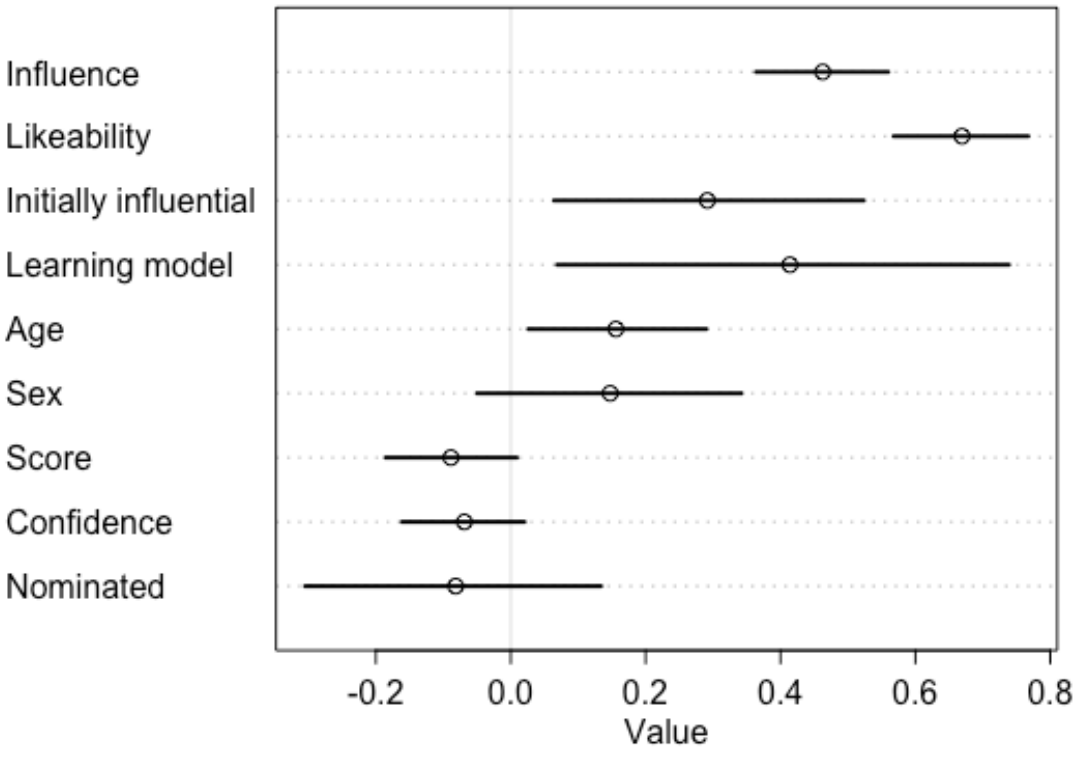


Figure 1: Parameter estimates for the full prestige model, with prestige ratings by other group members as the outcome. Estimates that cross zero suggest that parameter did not have a strong effect on prestige ratings.

Table 1: Model comparison for the prestige models, with prestige ratings by other group members as the outcome

Model	Parameters	WAIC	Weight	SE
Full	Score + influence + likeability + confidence + initially influential + learning model + age + sex + nominated + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	11034.1	0.65	124.13
A Priori	Score + influence + likeability + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	11035.3	0.35	123.65
Null	1|scale item + 1|RaterID + 1|RatedID + 1|Group	11053.3	0.00	123.63
Exploratory	Initially influential + learning model + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	11054.7	0.00	123.92

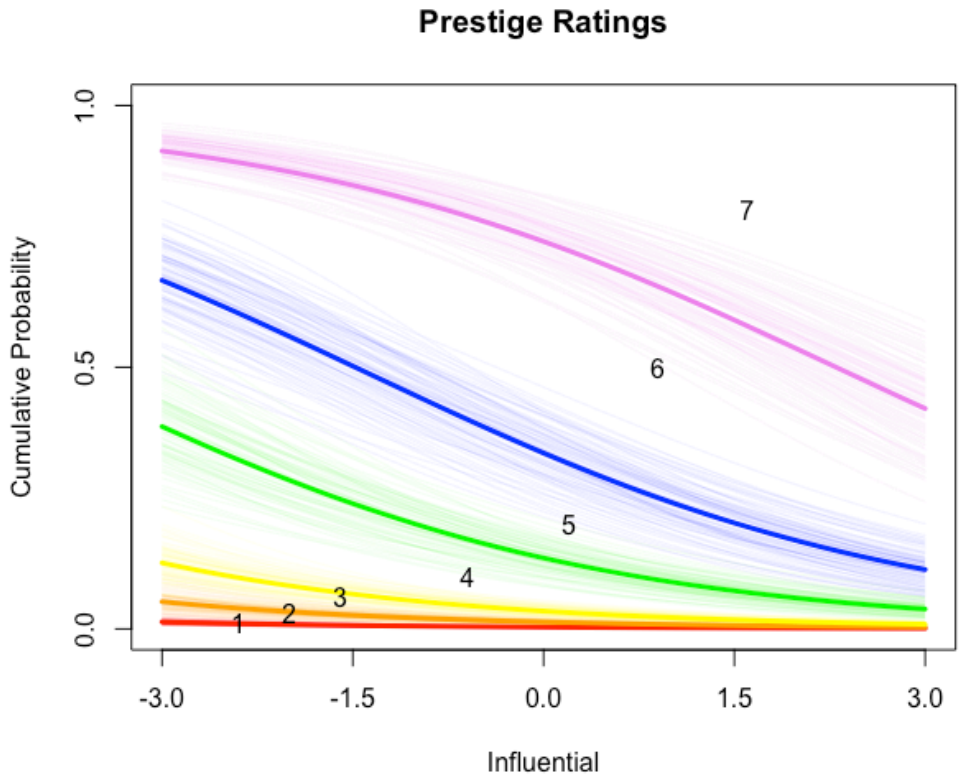


Figure 2: Posterior predictions of the ordered categorical prestige model showing how the distribution of each Likert scale response varies with influence ratings. The lines indicate boundaries between response values, numbered 1 to 7. The thick lines indicate the mean prediction for that boundary. If a participant is rated as highly influential, they are more likely to also be given a high prestige rating (e.g. 7) compared to less influential participants.

Turning to the dominance models (Fig 3, Table 2), in accordance with H3, participants were more likely to be rated as highly dominant if they were also rated as highly influential during the group task (0.55, CI:[0.41, 0.68], see Fig 4). Further analysis showed that dominance ratings were not predicted by prestige ratings, and thus dominance and prestige ratings were statistically independent from each other (0.71, CI:[-0.27, 1.69]), in line with H3. In accordance with H4, score on the quiz did not predict dominance ratings (-0.11, CI:[-0.24,0.03]). In contrast to H5, likeability negatively predicted dominance in that lower likeability ratings predicted higher dominance ratings (-0.48, CI:[-0.61,-0.35). Contrary to H6, however, overconfidence on the quiz did not predict higher dominance ratings (0.08, CI:[-0.05, 0.20]). (See Fig.4).

Aside from our a priori, hypothesis-based model, results from our full model suggested that participants were more likely to be rated as highly dominant if they were initially rated as an influential group member (0.50, CI:[0.17, 0.84]), and if they were older (0.26, CI:[0.10, 0.42]). Whether the participant was initially named as someone from whom others would like to learn did not predict high dominance ratings (-0.09, CI:[-0.52, 0.37]), nor did sex (0.25, CI:[-0.02,0.51]), or whether the participant was nominated for the bonus round (0.04, CI:[-0.27,0.34]). (See Fig.4).

The best fitting model was the full model, suggesting that other parameters were important aside from those in the a priori, dominance-based model. An exploratory model was compared in addition to the pre-registered models, to see if initial

ratings produced a better model fit than the dominance model, however this was not the case (see Table 2).

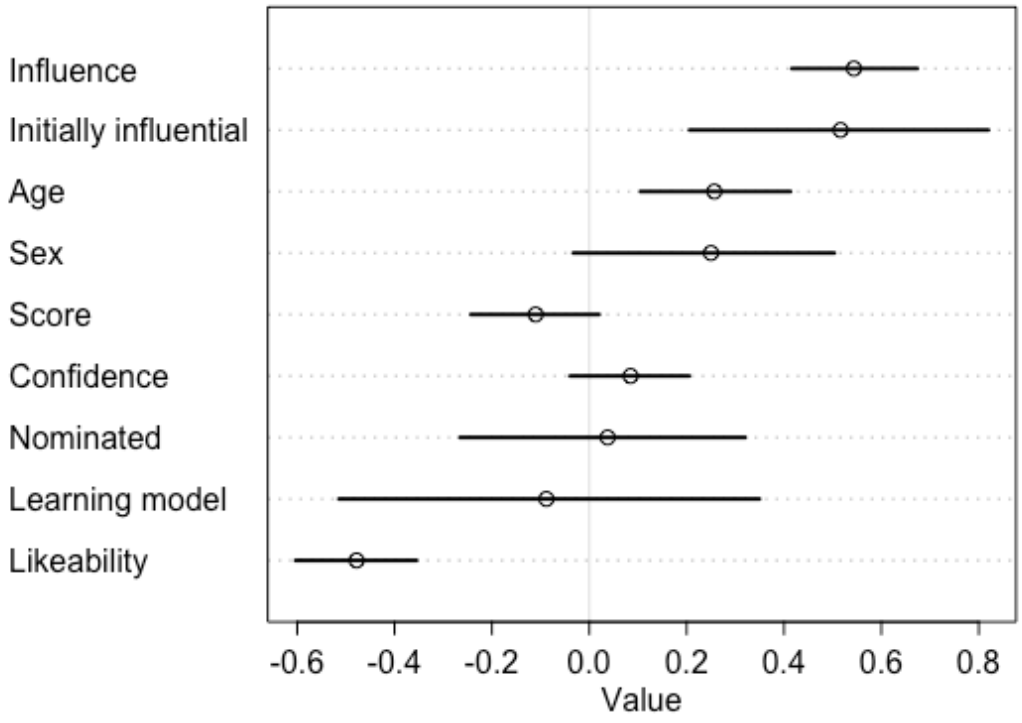


Figure 3: Parameter estimates of the full dominance model, with dominance ratings by other group members as the outcome. Estimates that cross zero suggest that parameter did not have a strong effect on dominance ratings

Table 2: Model comparison of the dominance models, with dominance rating by other group members as the outcome

Model	Parameters	WAIC	Weight	SE
Full	Confidence + influential + score + likability + nominated + initially influential + learning model + sex + age + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	10373.9	0.59	114.43
A Priori	Confidence + influential + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	10375.4	0.28	114.52
Null	1|scale item + 1|RaterID + 1|RatedID + 1|Group	10377.0	0.12	114.77
Exploratory	Initially influential + learning model + 1|scale item + 1|RaterID + 1|RatedID + 1|Group	10383.4	0.01	114.75

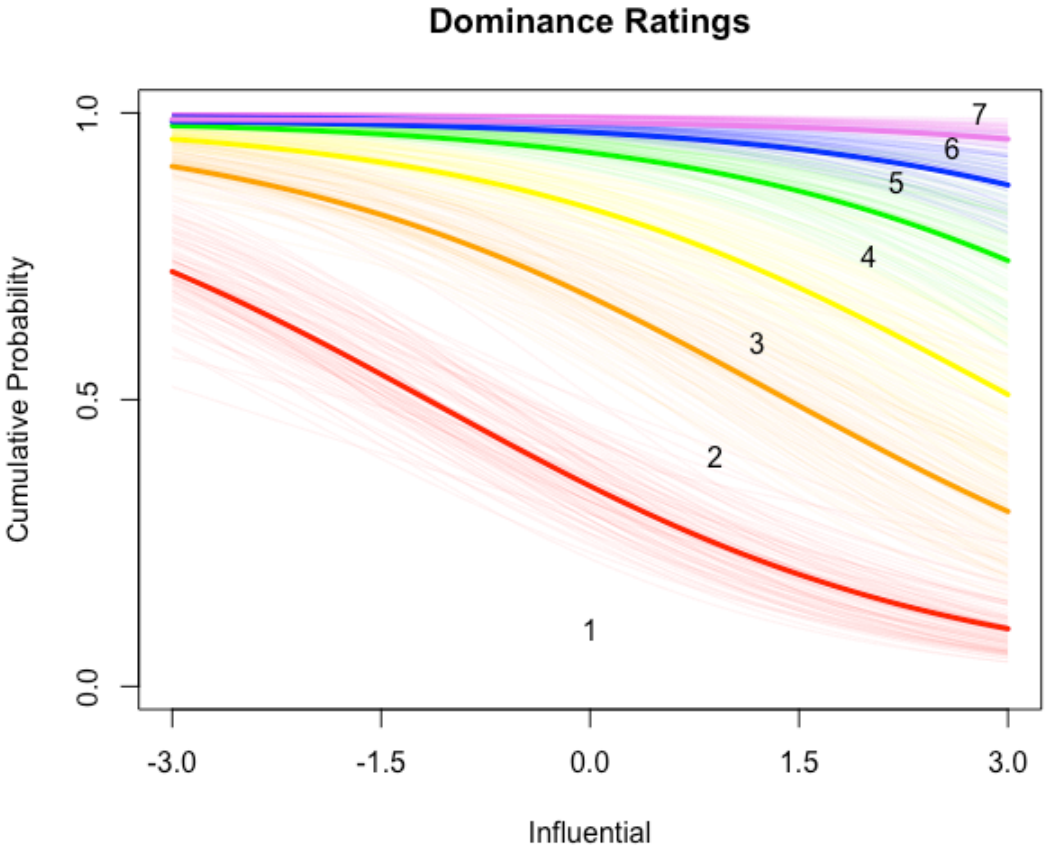
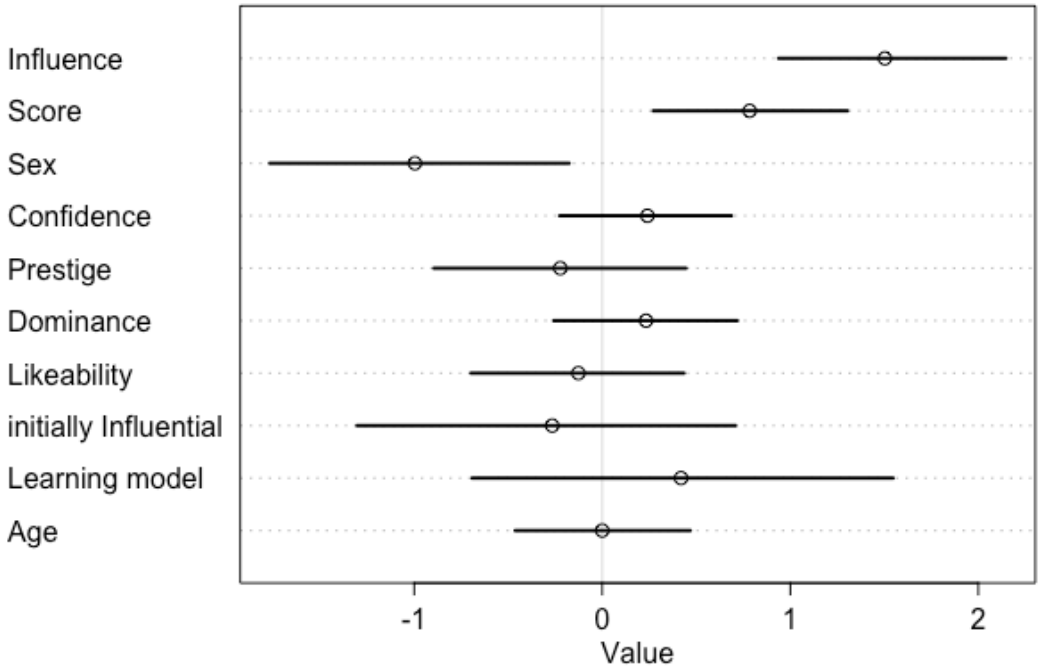


Figure 4: Posterior predictions of the ordered categorical dominance model showing how the distribution of each Likert scale response varies with influence ratings. The lines indicate boundaries between response values, numbered 1 to 7. The thick lines indicate the mean prediction for that boundary. If a participant has low influence, they are more likely to be given a low dominance rating (e.g. 1) compared to highly influential participants.

H7: Nominations

Hypothesis H7 was tested using nomination for the bonus quiz round as the outcome measure. While dominance failed to predict nominations for the bonus round as predicted, nor did prestige, which was expected to predict nominations (prestige: -0.22, CI: [-0.90,0.45], dominance: 0.23, CI:[-0.26,0.72]). (See Fig.5).

Aside from our a priori hypotheses, the full model suggested that participants were more likely to be nominated for the bonus round if they scored highly on the individual quiz (0.78, CI:[0.27,1.30]). Neither likeability, overconfidence on the quiz, nor age were related to nominations for the bonus round (likeability: -0.13, CI:[-0.70,0.44], confidence: 0.24, CI:[-0.23,0.69], age: 0.00, CI:[-0.46, 0.47]). Whether an individual held an influential position in the group, or was someone from whom others would like to learn, also had no relationship to nominations for the bonus round (initially influential: -0.27, CI:[-1.30,0.71], learning model: 0.42, CI:[-0.69,1.55]). However, participants were more likely to be nominated if they were rated as highly influential during the group quiz discussion (1.50, CI:[0.94,2.15]), and less likely if they were female (-1.00, CI:[-1.79,-0.18]), see Fig. 5.



493

Figure 5: Parameter estimates for the full nominations model, with likelihood of being nominated to represent the group in the bonus round as the outcome. Estimates that cross zero suggest that parameter did not have a strong effect on the likelihood of being nominated

494

495 The best fitting model was the full model, suggesting that other parameters were
496 important aside from those in our a priori model. An exploratory model was also
497 tested to see if score and confidence on the quiz provided a better fit than the other
498 a priori models, however this was not the case (see Table.3).

499

Table 3: Model comparison for the Nominations models, with likelihood of being nominated to represent the group in the bonus round as the outcome

Model	Parameters	WAIC	Weight	SE
Full	Intercept + score + confidence + prestige + dominance + influence + likeability + initially influential + learning model + 1|Group	108.6	1	13.43
Score model (exploratory)	Intercept + score + confidence + 1|Group	122.8	0	13.22
Influence model	Intercept + influence + 1|Group	130.3	0	11.00

Dominance model	Intercept + dominance + 1|Group	138.6	0	12.64
Previous relationships model	Intercept + initially influential + learning model + 1|Group	138.9	0	12.59
Null model	Intercept + 1|Group	140.6	0	12.37
Prestige model	Intercept + prestige + 1|Group	141.0	0	12.68
Likeability model	Intercept + likeability + 1|Group	142.7	0	12.78

Summary of hypotheses

In summary, H1 was partially supported, in that prestige and dominance ratings for influential wider community figures were not statistically independent, but they were negatively related, i.e. high prestige was associated with low dominance and vice versa. H2 was supported in that wider community figures from whom participants would like to learn have high prestige and low dominance, and prestige and dominance were unrelated. H3 was supported: influential group members were rated as both highly prestigious or dominant, and these were statistically independent. H4 was partially supported: while dominance was unrelated to quiz score as predicted, prestige was also unrelated, contrary to our predictions. H5 was partially supported: likeability was positively related to prestige as predicted, but dominance was negatively related to likeability, contrary to our prediction of no association. H6 was unsupported: confidence was unrelated to both prestige and dominance. Finally, H7 was partially supported: while dominance did not predict nominations for the bonus quiz, as expected, neither did prestige, contrary to our predictions.

DISCUSSION

We ran an experiment testing multiple aspects of theories of prestige and dominance with 30 naturally occurring groups in Cornwall. Participants completed a quiz individually and then as part of a team to win prize money. Participants anonymously voted for one team member to complete a bonus quiz on behalf of the group, providing a payoff-related, 'behavioural' measure of influence beyond self-reported ratings. Participants rated members of their wider community using scales of prestige and dominance, and anonymously rated the other members of their team using the same scales. Our methodology is novel in (i) using a demographically wide sample of participants within existing groups rather than university students brought together for the purpose of an experiment, and (ii) using a task explicitly tied to knowledge, allowing us to test theorised links between prestige and knowledge (and the absence of a link between dominance and knowledge).

We found that individuals' ratings of influence during the group quiz discussion were related to ratings of prestige and dominance, as found in previous studies (Cheng et al. 2013). Within-group ratings of prestige and dominance were also statistically independent from each other, as was found in previous studies (Cheng et al. 2013). However, contrary to our predictions, ratings of prestige and dominance did not predict who was voted for as team representative for the bonus quiz (our 'behavioural' measure of influence). Instead, participants voted for those who scored highly on the individual quiz, even though this information was unavailable to them. This suggests individuals were accurately able to assess

others' knowledge during the team discussion, and reliably vote for those who had the most knowledge, yet this knowledge did not translate to higher prestige ratings.

Although prestige and dominance ratings were unrelated to team nominations, we did find an unexpected relationship between initial ratings of within-group influence, and prestige and dominance ratings. That is, individuals who were initially named as having an influential role in the group such as team captain or group administrator, had higher prestige and dominance ratings than their team mates.

Taken together, these findings suggest that prestige and dominance may be more domain specific, or more fixed, than we had anticipated. As teams were already established, prestige and dominance ratings were better predicted by the individual's role in the group, rather than their performance on the quiz. Consequently, when voting for group representatives for a bonus quiz, group members did not vote for those with influential roles or high prestige and dominance, but voted for those with the highest quiz score. This suggests that prestige and dominance hierarchies develop over time within a group, but that these perceptions of dominance and prestige are not easily altered on a short-term basis, such as within the duration of our experiment. Alternatively, prestige could be highly domain-specific, and thus the prestige attained by showing expertise or knowledge in the activity practiced by the group (e.g. knitting or playing chess) did not transfer to the general knowledge required to answer our quiz questions. Previous findings that prestige predicts performance on tasks (e.g. Cheng et al. 2013) may therefore partially be a product of bringing strangers together with no prior relationships. In

565 the absence of such prior relationships, discussions during the experiment are the
566 only basis for prestige and dominance perceptions. This result also highlights that
567 researchers should control for, and be cautious of, any existing relationships within
568 participant samples, as these may be interfering or overriding any short-term
569 manipulations within the experimental set-up.
570
571 Interestingly, both members of the wider community, and members of the groups,
572 who participants named as someone from whom they would like to learn a skill, or
573 learn to be like, were rated as highly prestigious, but not highly dominant, as we
574 predicted. This finding supports the theory that prestige evolved in the context of
575 social learning, in that individuals who made particularly good learning models also
576 attained prestige from other members of their group (Henrich & Gil-White, 2001).
577 Likewise, our findings support the theory that dominant individuals do not make
578 good learning models, as their status is attained via threat or fear rather than
579 through skill or knowledge. Another distinguishing feature of individuals with high
580 prestige but not high dominance ratings was likeability, in that individuals who were
581 rated as highly likeable had higher prestige ratings on average, but lower
582 dominance ratings. Indeed, high dominance ratings predicted low likeability ratings.
583 This also supports previous studies that found highly prestigious individuals are
584 liked, whereas highly dominant individuals are not liked (Cheng et al., 2013).
585
586 Contrary to our predictions, overconfidence on the quiz did not predict dominance
587 ratings. A previous study found that prestige was related to authentic pride, whilst
588 dominance was related to hubristic pride (Cheng et al., 2010). However, neither

589 confidence, nor overconfidence in one's ability, predicted prestige or dominance
590 ratings in our task. Further work is needed to understand whether certain
591 personality factors contribute to an individual's likelihood of being perceived as
592 prestigious or dominant, and whether confidence is related to an individual's
593 likelihood of gaining prestige or dominance. It is worth noting that in our study,
594 prestige and dominance were related to positions of influence in the group that
595 were attained before our task, and that performance on our task was not related to
596 prestige and dominance ratings. Thus, the lack of relationship between confidence
597 on the quiz and prestige and dominance ratings in our case may be explained by
598 the lack of relationship between quiz performance and dominance/prestige ratings.
599
600 We did not have any specific predictions about sex or age in our study, however our
601 full models included effects of sex and age and were better-fitting models than our
602 hypothesis-based models. Age was related to prestige, in that older individuals
603 were rated as more prestigious than younger individuals. This supports previous
604 findings showing that age is positively related to prestige (Henrich & Henrich, 2010),
605 and supports the theory that older members of groups possess valuable skills and
606 knowledge that earn them prestige compared with younger members (although
607 other studies have failed to find support for this idea: Reyes-Garcia et al., 2008).
608 Age was also related to dominance ratings, with older individuals rated as more
609 dominant than younger individuals. Interestingly, women were less likely to be
610 nominated for the bonus round than men. This finding is particularly hard to
611 interpret given that women's individual quiz scores and likeability ratings were no
612 different to men's, however it may in part be due to women's lower average

613 confidence than men's, which is a widely-reported sex difference in a variety of
614 domains (Blanch, Hall, Roter, & Frankel, 2008; Cooke-Simpson & Voyer, 2007;
615 Syzmanowicz & Furnham, 2011). However, it is important to note that this result
616 was not part of our original predictions, thus these are only speculative, post-hoc
617 explanations. Further study and experimental evidence is required to interpret these
618 results with more certainty.
619
620 Worthy of note is that our study included a knowledge-based task rather than a
621 skill-based task, such as flint-knapping, knot-tying, basket-weaving, or spaghetti-
622 tower building, as used in many previous studies of social learning (Caldwell &
623 Millen 2008; Morgan et al. 2015; Zwirner & Thornton 2015; Caldwell et al. 2017).
624 Although Henrich and Gil-White did not distinguish between knowledge and skill in
625 their original discussion of prestige (Henrich & Gil-White, 2001), we feel it is an
626 important distinction to make and a necessary avenue of future research. One
627 reason for this distinction is the potential difference in observation and learning
628 opportunities for manual skills versus abstract knowledge. Current evidence of
629 social learning and cultural evolution in humans predominantly comes from either
630 ethnographic observations, or experimental tasks, in which a manual skill is learnt
631 via observation such as imitation or emulation. However, in contemporary post-
632 industrialised societies, it can be argued that the majority of learning opportunities
633 are not via direct imitation of a manual skill, but by acquiring knowledge, often via
634 language and explicit teaching. To what extent language interferes with, or
635 enhances, the social learning of knowledge (and indeed skills), needs to be
636 addressed. It is possible that success and prestige biases are crucial when socially

learning skills, but the transmission of knowledge may be governed by alternative social learning strategies that are not currently considered. Future research, using social learning experiments with language-mediated knowledge rather than skill as the focus, may help to address this distinction further.

In conclusion, we have found evidence that prestige and dominance hierarchies do exist in naturally occurring groups in a diverse, adult population. Although prestige ratings were not related to knowledge (quiz score), they were related to whether the individual held an influential position in the group already (such as team captain or group administrator). Furthermore, nominations for the bonus quiz were not predicted by prestige or dominance ratings, but were instead best predicted by the individual's score on the quiz. We interpret this as potential evidence of the domain specificity of prestige and dominance hierarchies, in that individuals who had attained their prestige or dominance through the group's regular activity were not nominated to represent the group on an unrelated task (the quiz). We encourage further work exploring the applicability of prestige and dominance measures in demographically diverse samples, as well as the theorised but under-studied link between prestige and knowledge. Finally, we recommend further investigation of the domain-specificity and generality of prestige and dominance.

Acknowledgements

This research was supported by The Leverhulme Trust (grant RPG-2016-122 awarded to AM). We thank Joey Cheng, Stefan Gehrig, Matt Gobel and Ángel Jiménez for useful comments on previous drafts. We also thank the community

groups who gave up their time to participate in our study, and the Royal Cornwall Polytechnic Society (The Poly), Falmouth for hosting a public event to disseminate our findings.

REFERENCES

Atkisson, C., O'Brien, M. J., & Mesoudi, A. (2012). Adult learners in a novel environment use prestige-biased social learning. *Evolutionary Psychology, 10*(3), 147470491201000309.

Blanch, D. C., Hall, J. A., Roter, D. L., & Frankel, R. M. (2008). Medical student gender and issues of confidence. *Patient Education and Counseling, 72*(3), 374–381. https://doi.org/10.1016/j.pec.2008.05.021

Bürkner, P.-C., & Vuorre, M. (2018). Ordinal regression models in psychology: A tutorial. *PsyArXiv*. https://doi.org/10.31234/osf.io/x8swp

Caldwell, C. A., & Millen, A. E. (2008). Experimental models for testing hypotheses about cumulative cultural evolution. *Evolution and Human Behavior, 29*(3), 165-171.

Caldwell, C. A., Renner, E., & Atkinson, M. (2017). Human teaching and cumulative cultural evolution. *Review of Philosophy and Psychology*, 1-20.

Cheng, J. T., Tracy, J. L., Foulsham, T., Kingstone, A., & Henrich, J. (2013). Two ways to the top: Evidence that dominance and prestige are distinct yet viable avenues to social rank and influence. *Journal of Personality and Social Psychology*, *104*(1), 103–125. https://doi.org/10.1037/a0030398

Cheng, J. T., Tracy, J. L., & Henrich, J. (2010). Pride, personality, and the evolutionary foundations of human social status. *Evolution and Human Behavior*, *31*(5), 334–347. https://doi.org/10.1016/j.evolhumbehav.2010.02.004

Cheng, J. T., & Tracy, J. L. (2014). Toward a unified science of hierarchy: Dominance and prestige are two fundamental pathways to human social rank. In *The psychology of social status* (pp. 3-27). Springer, New York, NY.

Chudek, M., Heller, S., Birch, S., & Henrich, J. (2012). Prestige-biased cultural learning: bystander's differential attention to potential models influences children's learning. *Evolution and Human Behavior*, *33*(1), 46–56. https://doi.org/10.1016/j.evolhumbehav.2011.05.005

Cooke-Simpson, A., & Voyer, D. (2007). Confidence and gender differences on the Mental Rotations Test. *Learning and Individual Differences*, *17*(2), 181–186. https://doi.org/10.1016/j.lindif.2007.03.009

Henrich, J., & Gil-White, F. J. (2001). The evolution of prestige: freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and Human Behavior*, *22*(3), 165–196. https://doi.org/10.1016/S1090-5138(00)00071-4

Henrich, J., & Henrich, N. (2010). The evolution of cultural adaptations: Fijian food taboos protect against dangerous marine toxins. *Proceedings of the Royal Society of London B: Biological Sciences*, *277*(1701), 3715–3724. https://doi.org/10.1098/rspb.2010.1191

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2-3), 61-83.

Liddell, T., & Kruschke, J. K. (2017). Analyzing ordinal data with metric models: What could possibly go wrong? Available at SSRN: https://ssrn.com/abstract=2692323 or http://dx.doi.org/10.2139/ssrn.2692323

Maner, J. K., & Case, C. R. (2016). Dominance and prestige: Dual strategies for navigating social hierarchies. *Advances in Experimental Social Psychology 54*, 129-180.

McElreath, R. (2016). *Statistical Rethinking*. CRC Press.

Morgan, T. J., Uomini, N. T., Rendell, L. E., Chouinard-Thuly, L., Street, S. E., Lewis, H. M., ... & Whiten, A. (2015). Experimental evidence for the co-evolution of hominin tool-making teaching and language. *Nature Communications, 6*, 6029.

Reyes-Garcia, V., Molina, J. L., Broesch, J., Calvet, L., Huanca, T., Saus, J., … McDade, T. W. (2008). Do the aged and knowledgeable men enjoy more prestige? A test of predictions from the prestige-bias model of cultural transmission. *Evolution and Human Behavior*, *29*(4), 275–281. https://doi.org/10.1016/j.evolhumbehav.2008.02.002

Syzmanowicz, A., & Furnham, A. (2011). Gender differences in self-estimates of general, mathematical, spatial and verbal intelligence: Four meta analyses. *Learning and Individual Differences*, *21*(5), 493–504. https://doi.org/10.1016/j.lindif.2011.07.001

Zwirner, E., & Thornton, A. (2015). Cognitive requirements of cumulative culture: teaching is useful but not essential. *Scientific Reports, 5*, 16781.