Evolutionary Psychology

www.epjournal.net – 2014. 12(1): 1-18

Original Article

Judgments of Dominance from the Face Track Physical Strength

Hugo Toscano, Centro de Investigação e Intervenção Social, Instituto Universitário de Lisboa (ISCTE-IUL), Portugal. Email: hmsto@iscte-iul.pt (Corresponding author).

Thomas W. Schubert, Department of Psychology, University of Oslo, Norway.

Aaron N. Sell, School of Criminology and Criminal Justice, Griffith University, Australia.

Abstract: It is commonly assumed that judgments of dominance from faces partly rely on implicit judgments of bodily strength. In two studies, we demonstrate such a relation for both computer-generated and natural photos of male faces. We find support when aggregating data across participants, when analyzing with hierarchical models, and also when strength and dominance are judged by different raters. Moreover, we identify common predictors that underlie perceptions of both strength and dominance: brow height, eye length, chin length, and the widths of the nose and mouth.

Keywords: dominance, physical strength, facial features, social hierarchies

Introduction

Judgments of dominance from the face track physical strength

One basic type of human social relationship is based on social hierarchies, with some individuals having greater access to resources and more control than others (Fiske, 1992). Similar, but much more rigid, social hierarchies occur in the species most closely related to us: chimpanzees, bonobos, and gorillas (Smuts, 1987). Social hierarchies of larger groups of humans are evident at least from the point at which chiefdoms were developed, and have been prevalent in human societies ever since (Boehm, 1999).

An individual who maintains a high rank in social hierarchies is referred to as *dominant*. High rank can be the outcome of various determinants; one likely determinant is bodily strength, important both to secure resources and prevail in dominance contests. In line with other recent arguments and evidence (e.g., Fink, Neave, and Seydel, 2007; Sell, Tooby, and Cosmides, 2009; Windhager, Schaefer, and Fink, 2011), here we provide evidence for the idea that judgments of dominance partly rely on judgments of bodily strength.

Facial maturity and dominance

Theories of interpersonal relations, perception, and judgment have long considered *dominance* as a central trait (Wiggins, 1979). For example, in the interpersonal circumplex model, the vertical axis of personality is dominance vs. submissiveness, with the second axis being cold vs. warm (Wiggins, Phillips, and Trapnell, 1989). When people perceive another individual, that individual is automatically categorized according to sex and age (Kurzban, Tooby, and Cosmides, 2001), but they are also judged spontaneously in terms of personality traits. Dominance is one of the two central traits judged from perceiving a human face. For instance, Oosterhof and Todorov (2008) used a series of principal component analyses to identify the dimensions underlying face evaluation. In a bottom-up approach, they started with more than 1000 trait inferences from faces, narrowed them down to 15 traits, and collected ratings of these traits, which were then analyzed. They found two dimensions that together accounted for more than 80% of the variance of trait judgments from faces. One of the dimensions was dominance, the other trustworthiness. The judgments of the traits dominant, mean, aggressive, and confident were the closest to the axis of the factor, with the trait dominant the most central. These findings led the authors to consider dominance as one of the dimensions of face evaluation.

Facial dominance correlates with social outcomes. Muller and Mazur (1997) found that West Point cadets with more dominant faces were more likely to attain higher ranks in their career. The influence of dominance can also be seen in the courtroom, where plaintiffs with more mature looking faces receive higher penalties than baby-face looking ones (Zebrowitz and McDonald, 1991). Facial dominance also predicts election outcomes (Chiao, Bowman, and Gill, 2008; Little, Burriss, Jones, and Roberts, 2007; Rule et al., 2010).

Dominance and strength

Social dominance is determined partly by actual physical strength, which predicts a man's rank in the social hierarchy in general (Von Rueden, Gurven, and Kaplan, 2008). The notion of social dominance is usually characterized as a superior likelihood in competitive contests of attaining the access to assets. Status is related with our chances of survival, reproduction, and kin protection (Cummins, 2005). Puts (2010), while discussing the mechanisms of sexual selection, posited that contests between men can be their central process of sexual selection. According to him, typically male features such as a larger body, more muscularity, and physically strength are related to males' evolutionary history of fighting and competition. Thus, individuals with more strength have a higher resource-hold potential or formidability (Parker, 1974). It is plausible that formidability contributes to status both because of advantages in inter-individual contests for higher ranks and also because it secures resources in contests with competitors outside of the hierarchy. Additionally, men with a higher ability to inflict costs on others have a higher fertility, which is related to social status (e.g., Von Rueden, Gurven, and Kaplan, 2011).

This reasoning suggests that mechanisms that evolved to perceive physical strength routinely contribute to the formation of social hierarchies, that is, dominance. Indeed, it would be zoologically unusual if it were not the case (Smuts, 1987). What is the evidence for this assumption? Some insights come from research on the baby face overgeneralization hypothesis. In general, this research tradition assumes that a number of traits are associated with individuals who are either very high or very low in babyfacedness, such as social submissiveness vs. dominance, social dependency vs. autonomy, physical weakness vs. strength, and so on. This line of work has referenced bodily strength, but it has rarely focused on it specifically.

For instance, Zebrowitz and Montepare (1992) investigated correlations between ratings of babyfacedness and ratings of physical weakness (among other variables). The two variables correlated for both male and female targets of all age groups after infancy, and judgments of physical weakness also correlated with the composite variables reflecting actual babyfacedness of the judged faces.

More recently, using handgrip strength as a proxy of human physical strength (Rantanen et al., 1999; Wind, Takken, Helders, and Engelbert, 2010), Fink et al. (2007) showed that women's ratings of men's dominance and masculinity based on faces correlated with those men's actual handgrip strength. Gallup, O'Brien, White, and Wilson (2010) also found that handgrip strength was positively correlated with self-ratings of dominance and aggression. Similarly, participants with more upper-body strength reported more aggressive behavior and entitlement (Sell, Tooby, et al., 2009). However, they do not show exactly relations between judgments of strength and dominance based on face.

Supporting evidence also comes from findings that dominance and strength judgments are determined by the same variables. For instance, Jones et al. (2010) created masculinized and feminized versions of target faces. Participants then judged the dominance and physical strength of those target persons. The masculinized versions were judged as both more dominant and physically strong.

Oosterhof and Todorov (2008), using a data driven statistical model (Blanz and Vetter, 1999; Facegen Main Software Development, 2006), rendered computer-generated faces varying along the dominance continuum and found that faces tended to be more mature and masculine in the positive extreme of the dominance axis. They assumed that dominance dimension was "an overgeneralization of perception of facial cues signaling the physical strength/weakness of the person" (p. 11091). Nonetheless, these participants were never asked to judge how physically strong they thought the person was.

Sell, Cosmides, et al. (2009) arrived at a similar idea. They tested what cues people use to accurately judge the actual strength of a person. The targets in their study were actually tested for their objective strength through weight-lifting tasks. Observers' judgments of physical strength correlated with the actual strength of these targets, both when they saw the whole body, and also when they only saw the face.

Thus, the idea that physical strength underlies dominance ratings follows from an analysis of the determinants of social dominance, has been prominently featured in arguments on both facial dominance and judgments of strength, and is in line with previous findings of the relation of judgments to actual physical strength. Here, we test directly whether judgments of physically strength are related to judgments of dominance when participants only see faces. Furthermore, we will take a variety of correlational approaches, including tests for correlations when the judgments of dominance and physical strength are coming from different participants.

Facial features of dominance and strength

In addition, we take a closer look at the facial features underlying such a correlation. We explore if there are common facial predictors for both strength and dominance. Zebrowitz (1997) showed that a babyface has large eyes, high eyebrows, small chin, round jaw, and high forehead. A face judged as dominant typically features small eyes, low brows, large chin, a more angular face and a low forehead (see also Keating, 1985; Lorenz, 1943). Studies of sexual dimorphism (e.g., Penton-Voak et al., 2001) reveal that males have a bigger jaw, and a more prominent brow ridge and cheekbones. Because masculinity can signal dominance (Muller and Mazur, 1997), more dominant faces share those characteristics. Schaefer, Mitteroecker, Fink, and Bookstein (2009) demonstrated that men's facial shape related to prenatal levels of testosterone was very similar to the facial shape that emerged from women's ratings of masculinity and dominance. More recently, Windhager et al. (2011) found that men's faces that were considered more dominant by women were more similar to physically strong faces. Using handgrip strength as a general measure of strength and with the help of a geometric morphometric (GMM) toolkit (e.g., Mitteroecker and Gunz, 2009), they were able to create a facial shape of men's strength. After that, they asked women to judge men's dominance. These researchers found that the dominant facial shape created on the basis of women's judgments resembled the physically strong facial shape. They found that faces considered more dominant by women and faces from men with a stronger handgrip had shorter noses, thinner lips and wider middle and lower faces. It remains to be seen, using both judgments of perceived physical strength and perceived dominance by the participants, if there are common facial features that can predict both judged physical strength and dominance.

Overview of the current research

In the current article, we present two studies. We test whether perceived physical strength is related to dominance judgments from the face. In addition, we explore which facial features are common predictors of both perceived strength and perceived dominance.

In Study 1, we used computer-generated faces (dimensions 400 x 400 pixels) from the set developed by Oosterhof and Todorov (2008). In the Study 2, we used a set of photos (dimensions 337 x 400 pixels) of male faces assembled by Sell, Cosmides, et al. (2009).[1]

We collected judgments of strength and dominance for all pictures from both datasets, and in addition measured all faces according to the dimensions described by Zebrowitz, Kikuchi, and Fellous (2007).

Materials and Methods

Method of both studies

Ethics statement. Both studies were conducted in agreement with the Ethics Guidelines issued in 2012 by the Scientific Commission (Comissão Científica) of the

[1] The faces used in our studies show some deviations from the Frankfort Horizontal which can limit the scope of interpretation of our facial measurements (see Schneider, Hecht, and Carbon, 2012).

hosting institution Centro de Investigação e Intervenção Social, Lisboa, Portugal (CIS-IUL).

Procedure. Data for both studies were collected online, using Qualtrics (www.qualtrics.com), and recruiting participants through Amazon Mturk (Buhrmester, Kwang, and Gosling, 2011). Participants were informed that the faces would appear twice with different questions, but the second question was not revealed until all judgments on the first question were completed. Participants were told there were no right or wrong answers and to answer intuitively.

Participants first judged all pictures on one of the dimensions (strength or dominance), and then all pictures again on the other dimension. The order of the two blocks was counterbalanced, and the order of pictures within a block was randomized.

The faces were presented at the center of the screen with the question below. The questions were "How physically strong is this person?" or "How dominant is this person?" for the two dependent variables, with response scales from 1 to 7 presented below the question, anchored with "very weak" and "very strong," or "not at all dominant" and "very dominant," respectively.

Before the dominance block, we explained that by dominance we meant "how much this person wants to influence other people and how much she or he is able to do so."[2] For strength, no such explanation was deemed necessary.

Facial metrics. We measured the facial features with a procedure based on the one used in Zebrowitz, Kikuchi, and Fellous (2007). Each face was loaded into software developed by us using Processing (http://processing.org/). In this software, 40 facial points were marked (see Figure 1) in all faces. These points were all marked independently for all pictures by three research assistants. All distances used by Zebrowitz were used, and two more were added (Z1 and Z2). All measures were normalized by the inter-pupil distance (E2) (see details of measurement in Zebrowitz et al., 2007)[3]. We had 24 facial distance measures in total (see Figure 1). One of these was the normalization distance (E2), and one was the composite distance Facial Roundness. The other measures corresponded to facial features of the brows, eyes, cheekbones, nose, chin, and head length. More specifically, we measured the inner eyebrows distance (B1), distances related with brow height (B2 to B6), the distance between the inner corners of eyes (E1), distance between the outer corners of eyes (E3), eye width (E4), eye length (E5), nose width (N2) and nose length (N3), the head length (L0), length of the jowl (S0), distance from the pupil to the center of the chin (C1), chin length (C3), mouth width (M0), philtrum length (M3), thickness of the upper lip (M4), lower facial width (W1), head width (W4), cheekbones width (W6), the Z2 thickness of the lower lip (Z2) and the length from the beginning of the hair until the end of the head (Z1).

There was a high inter-rater reliability for all facial measures. The measurements showed a high agreement for the normalization distance (E2) for both Study 1 (α = .98) and

[2] In this broad definition we thus include both potential and motivation for influence. Influence is a key aspect of social ranking/status (e.g., Cheng, Tracy, Foulsham, Kingstone, and Henrich 2013).

[3] It should be referred that this standardization through the inter-pupil distance is not able to erase the size cues from the faces. Because of the importance of height cues in judgments of human face (e.g., Re, DeBruine, Jones, and Perrett 2013), we recognize that this may influence the judgments of our participants.

Study 2 (α = .99). The average inter-rater reliability for all facial metrics showed a strong agreement for the Study 1 database faces (α = .85) and for Study 2 faces (α = .93) (see Table 1). We then averaged across the three raters all the facial distances measured and used these means in all following analyses.

Figure 1. Measurement of facial metrics through marking of 40 reference points

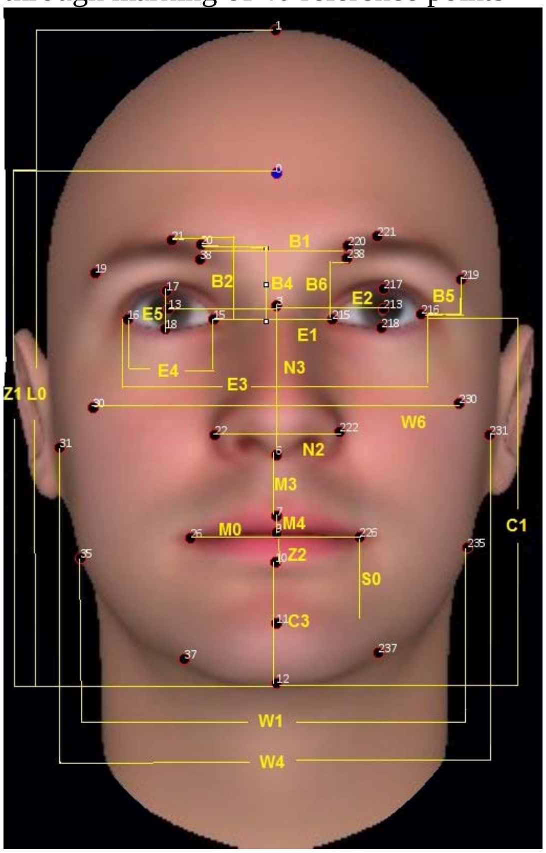


Table 1. Average inter-rater reliability of facial features for face database of Studies 1 and 2

Feature	ICC Study 1	ICC Study 2
B1	.72**	.90**
B2	.97**	.99*
B4	.92**	.99**
B5	.67**	.97**
B6	.96**	.92**
E1	.92**	.96**
E3	.97**	.94**
E4	.89**	.89**
E5	.83**	.97**
N2	.95**	.99**
N3	.82**	.96**
M0	.95**	.84**
M3	.89**	.94**
M4	.69**	.97**
S0	.65**	.95**
C1	.93**	.99**
C3	.93**	.98**
W1	.98**	.59**
W4	.97**	.96**
W6	.68**	.90**
L0	.96**	.97**
Z1	.52**	.91**
Z2	.84**	.97**
Facial Roundness	.75**	.81**

Note: ** $p < .001$

Study 1

Participants

We recruited 69 participants (41 female) from the United States of America (USA) and Western Europe through MTurk and paid each \$0.50. The mean age was 34.5 years (*SD* = 13.99, range 18 – 77).

Materials

Participants judged 60 computer-generated faces developed by Oosterhof and Todorov (2008; see Figure 2). The pictures were created with FaceGen software (Facegen Modeller program version 3.1, http://facegen.com). The rendered pictures show heads of mostly White faces of both genders (for some faces, gender and ethnicity is hard to judge) without hair or clothing.

Figure 2. Examples for the Stimuli in Study 1 (Database developed by Oosterhof and Todorov, 2008)

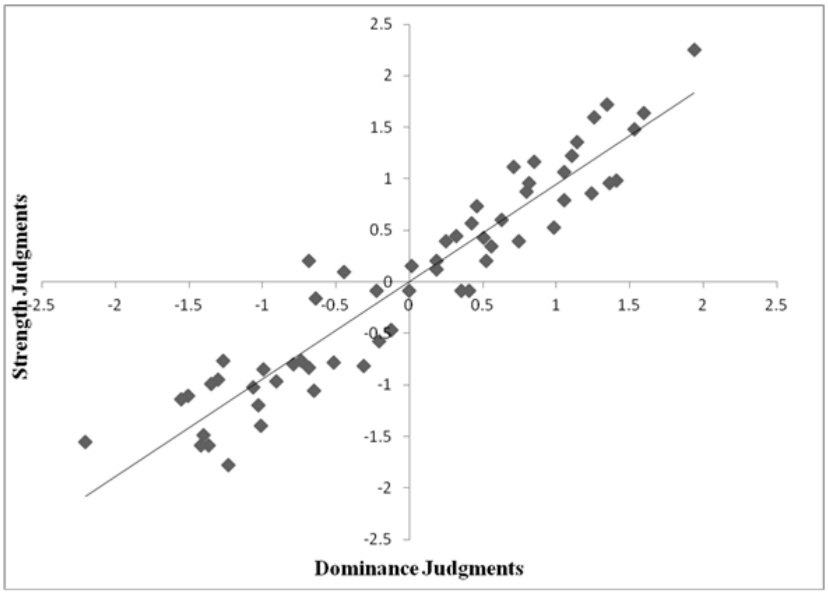
Results

We used Linear Mixed Models (also known as hierarchical linear modeling) to analyze the relation between ratings of strength and ratings of dominance, and the mediation of this relation by facial features. For the mixed models, the units of analysis were the single judgments made by the participants regarding dominance. Both picture and participant were added as groupings of the observations. For both pictures and participants, the intercepts were allowed to vary randomly. The dependent variable was ratings of dominance.

In the first model, we introduced ratings of strength, order of ratings (strength first vs. dominance first), gender of participant, and their interactions as independent and fixed factors. We estimated this model with the Mixed procedure in SPSS 18. The strength and dominance ratings were z-standardized (based on grand mean) prior to analysis. This model showed that perceived strength was a significant predictor of perceived dominance, $F(1, 3933.14) = 247.89$, $\beta = .26$, $p < .001$. Gender had no effect, $F(1,61.94) = 0.10$, $p = .76$, and neither did order of judgment, $F(1, 61.90) = 0.64$, $p = .53$. There was no interaction between gender and order, $F(1, 61.92) = 0.15$, $p = .86$.

It is possible that the second judgment assimilated to the first judgment. In order to check for this possibility, we needed to resort to aggregated values. We aggregated ratings of dominance and strength for each picture across participants, thereby creating a dataset where the single pictures were the units of analysis. Note that aggregation across so many observers reduces error variance, resulting in higher correlations overall. After that, we standardized the dominance and strength judgments. We did Pearson correlations between ratings of strength and ratings of dominance. A first correlation was computed using both judgments participants gave, with each picture as the unit of analysis. The correlation was very high, $r = .95$, $p < .001$. We then repeated this analysis using only the first answer each participant gave for the aggregation. The correlation obtained was about the same, $r = .94$, $p < .001$. This indicates that, for this sample, a face that was perceived – on average – to be dominant was also perceived to be strong (see Figure 3), even when both judgments came from different participants who did not judge the other dimension first.

Figure 3. Scatter plots of *z*-standardized mean judgments of strength and mean judgments of dominance



We then tested which facial features predicted judgments of dominance and strength. For this, we ran two models. In the first, dominance was the dependent variable, and all facial features were added as independent variables. Pictures and participants were again added as groupings, letting the intercepts vary randomly across both. The second model was the same except that strength was the dependent variable. We then identified which predictors were significant in both models.

In the outcomes of these models, we identified facial characteristics that predicted both dominance and strength (see Table 2). There were three: brow height (negatively, $\beta = -0.51$, $p = .006$ for dominance and $\beta = -0.40$, $p = .037$ for strength, B6), eye length (negatively, $\beta = -0.25$, $p = .011$ for dominance and $\beta = -0.26$, $p = .013$ for strength, E5), and nose width (positively, $\beta = 0.15$, $p = .005$ for dominance and $\beta = 0.14$, $p = .013$ for strength, N2). In addition, mouth width (M0) marginally (negatively) predicted dominance ($\beta = -0.09$, $p = .078$) and strength ($\beta = -0.09$, $p = .106$). In sum, a person with a wide nose, narrow (vertically) eyes, low brows and a narrow mouth is simultaneously seen as strong and dominant. There was one facial feature - head width - that only predicted dominance (negatively, $\beta = -0.34$, $p = .04$ for dominance and $\beta = -0.17$, $p = .338$ for strength, W4). There was no facial feature that predicted strength but not dominance (see Table 2).

Table 2. Facial features relation with dominance and physical strength judgments - Study 1

Study 1	Dominance				Strength			
Feature	*β*	*p*	95% CI low	95% CI up	*β*	*p*	95% CI low	95% CI up
B1	0.02	.786	-0.10	0.13	0.04	.516	-0.09	0.17
B2	0.08	.532	-0.19	0.36	0.02	.915	-0.28	0.31
B4	0.22	.310	-0.21	0.64	0.20	.381	-0.26	0.66
B5	0.06	.368	-0.08	0.21	0.07	.377	-0.09	0.23
B6	-0.51	.006	-0.86	-0.16	-0.40	.037	-0.78	-0.03
E1	1.39	.110	-0.33	3.10	0.12	.901	-1.74	1.97
E3	-1.58	.118	-3.58	0.42	-0.20	.852	-2.36	1.97
E4	2.54	.104	-0.55	5.62	0.31	.853	-3.03	3.64
E5	-0.25	.011	-0.43	-0.06	-0.26	.013	-0.46	-0.06
N2	0.15	.005	0.05	0.25	0.14	.013	0.03	0.25
N3	-0.16	.234	-0.44	0.11	-0.01	.968	-0.30	0.29
M0	-0.09	.078	-0.19	0.01	-0.09	.106	-0.20	0.02
M3	0.09	.323	-0.09	0.27	0.04	.649	-0.15	0.24
M4	-0.04	.549	-0.19	0.10	-0.04	.604	-0.20	0.12
S0	-0.15	.332	-0.45	0.16	-0.09	.594	-0.41	0.24
C1	-0.23	.480	-0.89	0.43	0.31	.388	-0.41	1.02
C3	0.17	.380	-0.22	0.57	0.13	.556	-0.30	0.55
W1	0.06	.577	-0.15	0.26	0.17	.125	-0.05	0.39
W4	-0.34	.040	-0.67	-0.02	-0.17	.338	-0.53	0.19
W6	0.01	.887	-0.16	0.19	-0.03	.767	-0.22	0.16
L0	0.28	.350	-0.32	0.88	-0.15	.650	-0.80	0.50
Z1	-0.08	.560	-0.34	0.19	-0.13	.378	-0.41	0.16
Z2	0.02	.771	-0.12	0.16	0.11	.159	-0.04	0.26
Facial Roundness	0.30	.086	-0.04	0.64	0.05	.780	-0.32	0.42

Discussion

In Study 1, when participants judged computer-generated faces, perceptions of strength and ratings of dominance were closely related, as shown both in the mixed model analysis and in the correlations based on aggregated values. Importantly, this was also the case when those ratings came from different participants (always using the first rating). Order of ratings and gender of participants did not make any difference.

Our analysis of facial features identified a wide nose, short (vertically) eyes, low brows, and a narrow mouth as common predictors of strength and dominance. A less wide head predicted dominance but not strength.

One problem with the second step of our analysis is that we investigated a large number of predictors simultaneously in the multilevel models. This has the potential to create false positives through accumulated alpha error. These results should thus be interpreted as exploratory and subject to replication. Study 2 aims at providing such a replication. There, we will jointly consider significance and inclusion in confidence intervals as criteria for replication.

Study 2

Study 2 was conducted to replicate the findings from Study 1 with photos of real faces instead of computer-generated pictures.

Participants

We recruited and paid 135 (78 female) participants from the USA and Western Europe as in Study 1. The mean age was 35.61 years (*SD* = 11.87, range 18 – 66).

Materials

We used 62 photos of male faces (mean age: 21.1 years, *SD* = 2.4, range 18 – 32; 62% Euro-American, 15% Asian-American, 5% African-American, 2% Middle Eastern, 5% Hispanic, 11% other, with no significant differences in strength as a function of ethnicity) assembled by Sell, Cosmides, et al. (2009; see Figure 4).

Figure 4. Example of the stimuli in Study 2 (Database developed by Sell, Cosmides, et al., 2009)

Results

We again set up a mixed model, predicting ratings of dominance from ratings of strength, adding participant gender as a fixed factor, and both participant and picture as grouping variables, allowing the intercepts to vary across them. Judgments of strength predicted judgments of dominance, $F(1, 8268.30) = 718.44$, $\beta = 0.29$, $p < .001$. Gender had no effect, $F(1, 132.85) = 0.21$, $p = .652$. Because of a software failure in Qualtrics, order of scales was not recorded. Note however that order had no effect in Study 1.

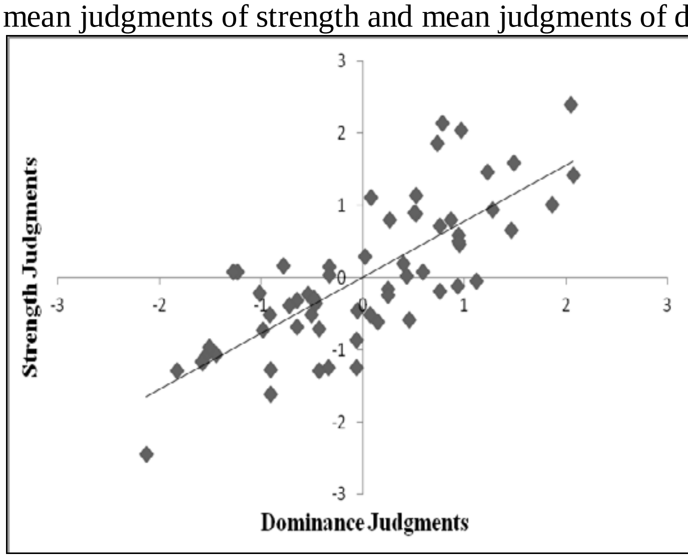
We then proceeded by creating aggregate scores, averaging ratings of strength and dominance across participants. We standardized these judgments and conducted Pearson correlations. The correlation of these two aggregated variables was somewhat lower than for artificial faces, though still quite high, $r = .78$, $p < .001$.

We also analyzed whether judgments in our study were related to the actual upper body-strength of the judged targets (targets were assessed on weight lifting machines; see details in Sell, Cosmides, et al., 2009). We used the aggregated values for these analyses for the Pearson correlations (see Figure 5). Actual upper body strength was correlated both with judgments of strength ($r = .54$, $p < .001$) and the judgments of dominance ($r = .34$, $p < .001$). In other words, men with objectively stronger upper bodies are judged as stronger and as more dominant purely relying on facial characteristics. To tease apart these relations, we computed partial correlations. When controlling for dominance judgments, the partial correlation between judged strength and actual strength remained significant, $r = .46$, $p < .001$. However, when controlling for judgments of strength, the partial correlation between dominance and the actual strength was not significant $r = -.14$, $p = .308$.

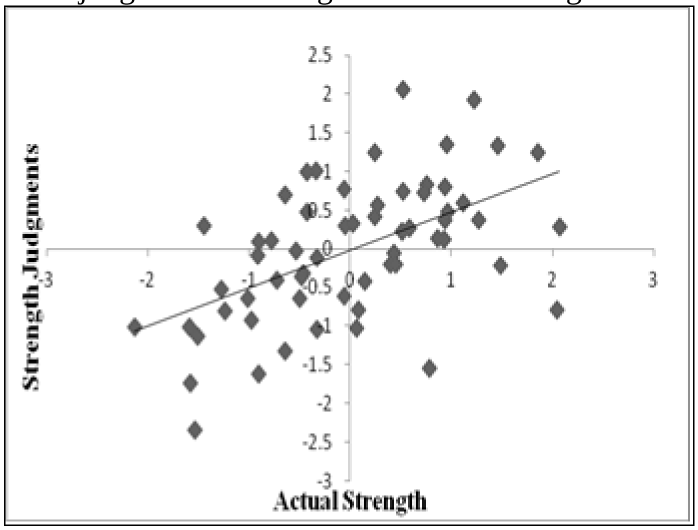
We then repeated the analyses performed in Study 1 (see Table 2) to determine which facial features predict both strength and dominance. We found fewer common predictors than in Study 1. Brow height (B6) predicted dominance significantly (negatively), $\beta = -0.38$, $p = .004$ and strength marginally, $\beta = -0.26$, $p = .072$. Eye length (E5) predicted marginally both dominance (also negatively), $\beta = -0.19$, $p = .071$ and strength, $\beta = -0.22$, $p = .079$. Finally, chin length (C3) predicted (positively) dominance, $\beta = 0.58$, $p = .024$ and marginally predicted strength, $\beta = 0.54$, $p = .061$. In sum, a man featuring low brows, (vertically) narrow eyes, and large chin will be judged as both strong and dominant.

Figure 5. Scatter plots of:

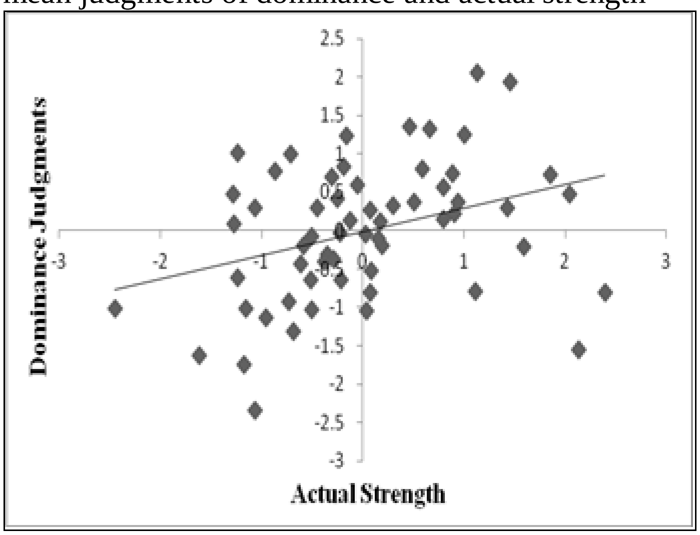
A) *z*-standardized mean judgments of strength and mean judgments of dominance



B) *z*-standardized mean judgments of strength and actual strength



C) *z*-standardized mean judgments of dominance and actual strength



We found facial features that predicted dominance but not strength and vice versa. Nose length (N3) predicted dominance significantly (positively), $\beta = 0.26$, $p = .05$ but not strength, $\beta = 0.11$, $p = .484$. Distance from the pupil to the center of the chin (C1) predicted dominance significantly (negatively), $\beta = -0.54$, $p = .002$ but not strength, $\beta = -0.28$, $p = .156$. Brow height (B2) marginally predicted strength (positively), $\beta = 0.55$, $p = .052$ but not dominance, $\beta = 0.30$, $p = .207$.

However, the facial features of nose width (N2) and mouth width (M0) that predicted both dominance and strength in Study 1, did not show the same pattern in Study 2. Nose width (N2) did not predict dominance $\beta = 0.10$, $p = .253$ or strength, $\beta = 0.10$, $p = .333$. Finally, mouth width (M0) marginally predicted dominance (negatively), $\beta = -0.12$, $p = .081$, but did not predict strength, $\beta = 0.04$, $p = .565$.

Nonetheless, the β-values for nose width (dominance: $\beta = 0.10$; strength: $\beta = 0.10$)

are within the Study 1 confidence intervals for dominance (0.05; 0.25) and physical strength (0.03; 0.25). Consequently, it is likely that Study 1 overestimated the strength of this cue, but that this cue is still important. The estimates of mouth width (M0, dominance β = -0.12; strength: β = 0.04) fall within the limits of the confidence intervals of Study 1 only for dominance judgments (-0.19; 0.01), but not for physical strength judgments (-0.20; 0.02). Thus, Study 2 contradicts Study 1 here, and M0 is likely not used as a cue to physical strength, but only used as a cue for dominance (see Table 3).

Table 3. Facial features relation with dominance and physical strength judgments - Study 2

Study 2	Dominance				Strength			
Feature	β	*p*	95% CI low	95% CI up	β	*p*	95% CI low	95% CI up
B1	0.09	.271	-0.07	0.24	0.10	.255	-0.08	0.28
B2	0.30	.207	-0.17	0.78	0.55	.052	0.00	1.10
B4	-0.19	.456	-0.71	0.33	-0.54	.076	-1.14	0.06
B5	0.08	.357	-0.10	0.27	0.05	.613	-0.16	0.27
B6	-0.38	.004	-0.62	-0.13	-0.26	.072	-0.55	0.02
E1	-1.09	.216	-2.83	0.66	-1.40	.167	-3.41	0.61
E3	1.39	.217	-0.85	3.64	1.68	.197	-0.91	4.27
E4	-2.11	.238	-5.68	1.46	-2.60	.208	-6.71	1.51
E5	-0.19	.071	-0.40	0.02	-0.22	.079	-0.46	0.03
N2	0.10	.253	-0.07	0.27	0.10	.333	-0.10	0.29
N3	0.26	.050	0.00	0.52	0.11	.484	-0.20	0.41
M0	-0.12	.081	-0.25	0.02	0.04	.565	-0.11	0.20
M3	0.15	.095	-0.03	0.32	0.04	.707	-0.16	0.24
M4	0.07	.524	-0.14	0.27	-0.01	.902	-0.25	0.22
S0	-0.15	.489	-0.59	0.29	-0.23	.353	-0.74	0.27
C1	-0.54	.002	-0.88	-0.21	-0.28	.156	-0.67	0.11
C3	0.58	.024	0.08	1.07	0.54	.061	-0.03	1.11
W1	0.09	.511	-0.18	0.35	0.25	.103	-0.05	0.55
W4	0.01	.939	-0.35	0.38	-0.12	.571	-0.54	0.30
W6	-0.08	.520	-0.34	0.17	-0.08	.597	-0.37	0.22
L0	0.00	.970	-0.24	0.25	-0.09	.537	-0.37	0.20
Z1	0.33	.125	-0.10	0.75	0.40	.105	-0.09	0.89
Z2	-0.01	.912	-0.22	0.20	-0.04	.723	-0.28	0.20
Facial Roundness	0.08	.439	-0.13	0.29	0.16	.181	-0.08	0.41

General Discussion

In the current paper, we demonstrate a relation between perceived strength and perceived dominance for both computer-generated faces (Study 1) and photos of male faces (Study 2). In both studies, using multilevel modeling, we found that judgments of dominance were predicted by judgments of strength. When aggregating data across participants, and taking picture as the unit of analysis, the correlation is larger than .90 for computer-generated faces and larger than .70 for real faces. Importantly, this correlation remains unchanged when the strength and dominance were judged by different raters.

Notably, the correlation between aggregated values of strength and dominance is lower for the natural photos in Study 2 than for the computer-generated in Study 1. (Note that Matheson and McMullen, 2011, showed that computer-generated faces have the same perceptual and memory processing as natural faces). This could be the result of some real targets not having perfectly neutral expressions, or not being uniformly bald, and thereby providing other cues of dominance along with the cues related to strength alone (e.g., perhaps cues of hostility). However, it should be noted that the coefficients in the mixed model did not differ substantially from each other.[4]

For the targets judged in Study 2, we had measurements of their actual upper-body strength. Our data show that both the judgments of strength and dominance were related to actual strength. In other words, it is not only the case that dominance judgments are related to strength judgments, but also to actual strength. Thus, it seems that (accurately judged) actual strength might serve as a cue to dominance. Even though in typical Western social environments social status between adults is rarely negotiated based on physical strength except in sports contests, both males and females base their dominance judgments partly on facial cues of strength.

However, the modest correlation between dominance judgments and actual strength, and also the finding that the relation between dominance and actual strength become non-significant when controlling for judged strength, suggest that perceivers use other cues to judge dominance as well. During human evolution, physical strength was an important basic heuristic for social status given that it predicted the ability to inflict costs. Nonetheless, the mental skills associated with leadership, the ability to solve problems, and material possessions would also be important for a higher social dominance because of their likelihood of increasing the ability to give benefits to others. Thus, not only the increasing ability to win physical contests (i.e., greater physical strength), but also a greater influence in the community through the benefits that they are able to confer to the general population suggest that both processes can be avenues to perception of social dominance. In tribal societies we can see that, for example, hunting skills, knowledge about migration cycles of animals, and being elderly are linked to a higher social status. In industrial societies social status is probably even less related to physical strength and more associated with intelligence, social skills, and technological expertise (Cheng et al., 2013; Henrich and Gil-White, 2001; Von Rueden et al., 2011).

Going beyond the identification of a relation between strength and dominance, we identified common cues that may enable the assessment of strength and dominance. For the

[4] We conducted another study that is not reported in detail here, which replicated Study 1 with a larger sample (i.e., 300) of computer-generated faces. In that study, the correlation between the aggregated values of strength and dominance was slightly lower than in Study 1, r = .84, p < .001. Thus, it seems that the difference between Study 1 and Study 2 is less substantial than one might think.

natural faces the common predictors of high dominance and strength ratings were low brows (B6), narrow (vertically) eyes (E5), and large chins (C3). In computer-generated faces, common predictors were low brows (B6), narrow (vertically) eyes (E5), and wide noses and narrow mouths (N2 and M0).

In previous studies, these facial features were already linked with dominance judgments. For instance, the baby face overgeneralization hypothesis (e.g., Zebrowitz, 1997) posits that because babies have certain facial characteristics, people will judge persons according to those. Thus if someone has small eyes, large chins and low brows people will tend to see those faces as resembling a mature adult because babies show the opposite pattern. Curiously, Dotsch and Todorov (2012) used a reverse correlation method with natural faces and revealed that the most diagnostic facial cues of dominance were the regions around the eyes and the delineation of the face where they included the chin. Windhager et al. (2011) showed that the main regions related with perceived dominance were a wide lower face, a short nose and small eyes. Although there were some differences with the facial regions found in our research, these studies give support to the idea that the main regions to track strength are essential to track dominance. We recognize that our method of identifying these facial features shows some limitations. Because faces are processed in a holistic way, that is, people tend to perceive and judge faces as a whole and not as an identity of separated and independent features, this process of measuring multiple facial distances between landmark points in space tends to ignore the general facial shape (Holland, 2009).

It's important to add that our data by no means suggest that judgments of social dominance and judgments of bodily strength are the same. As the study of Windhager et al. (2011) revealed, strong faces and dominant faces are not identical. In their research, they were able to show that strong and dominant facial shapes showed differences in certain facial regions like the eyes, the eyebrows, the mouth, the chin, and the region between the eyes and eyebrows. In our study, there were also differences in the facial features predicting dominance and physical strength. More specifically, for the computer-generated faces, the head width negatively predicted dominance but did not predict strength. Moreover, in the natural faces we were able to show that a larger nose and a shorter distance from the pupil to the center of the chin predicted dominance, but not physical strength. Additionally, one of the measures related with the brow height (B2) predicted strength, but not dominance. Besides that, the relation identified in the multilevel model clearly suggests that a substantial part of variance in dominance judgments is not related to bodily strength. It remains a task for future work to investigate where the two dimensions might diverge despite the strong relation we found here.

In sum, we extend the knowledge related with the notion that dominance and strength ratings go hand in hand, even when collecting these data from different participants and when tested on computer-generated and natural faces. Dominance judgments are based on strength ratings, backed up by the findings that actual bodily strength predicts dominance.

Received 7 June 2013; Revision submitted 7 October 2013; Accepted 10 October 2013

References

Blanz, V., and Vetter, T. (1999). A morphable model for the synthesis of 3D faces. *Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Techniques* (pp. 187–194). ACM Press/Addison-Wesley Publishing Co.

Boehm, C. (1999). *Hierarchy in the forest*. Cambridge: Harvard University Press.

Buhrmester, M., Kwang, T., and Gosling, S. D. (2011). Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data? *Perspectives on Psychological Science, 6*, 3–5.

Cheng, J. T, Tracy, J. L., Foulsham, T., Kingstone, A., and 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,* 103–125.

Chiao, J. Y., Bowman, N. E., and Gill, H. (2008). The political gender gap: Gender bias in facial inferences that predict voting behavior. *PloS ONE*, *3*, e3666.

Cummins, D. D. (2005). Dominance, status, and social hierarchies. In D. M. Buss (Ed.), *The evolutionary psychology handbook* (pp. 676–697). Hoboken, NJ: Wiley.

Dotsch, R., and Todorov, A. (2012). Reverse correlating social face perception. *Social Psychological and Personality Science, 3*, 562–571.

Facegen Main Software Development Kit 3.1. (2006). Vancouver, BC: Singular Inversions.

Fink, B., Neave, N., and Seydel, H. (2007). Male facial appearance signals physical strength to women. *American Journal of Human Biology, 19*, 82–87.

Fiske, A. P. (1992). The four elementary forms of sociality: Framework for a unified theory of social relations. *Psychological Review, 99*, 689–723.

Gallup, A. W., O'Brien, D. T, White, D. D., and Wilson, D. S. (2010). Handgrip strength and socially dominant behavior in male adolescents. *Evolutionary Psychology, 8*, 229–243.

Henrich, J., and Gil-White, F. (2001). The evolution of prestige: Freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and Human Behavior, 22*, 165–196.

Holland, E. (2009). Limitations of traditional morphometrics in research on the attractiveness of faces. *Psychonomic Bulletion & Review, 16*, 613–615.

Jones, B. C., DeBruine, L. M., Main, J. C., Little, A. C., Welling, L. L., Feinberg, D. R., and Tiddman, B. P. (2010). Facial cues of dominance modulate the short-term gaze-cuing effect in human observers. *Proceedings of the Royal Society B, 277*, 617–624.

Keating, C. F. (1985). Gender and the physiognomy of dominance and attractiveness, *Social Psychology Quarterly, 48*, 61–70.

Kurzban, R., Tooby, J., and Cosmides, L. (2001). Can race be erased? Coalitional computation and social categorization. *Proceedings of the National Academy of Sciences*, *98*, 15387–15392.

Little, A. C., Burriss, R. P., Jones, B. C., and Roberts, S. C. (2007). Facial appearance affects voting decisions. *Evolution and Human Behavior, 28,* 18-27.

Lorenz, K. (1943). Die angeborenen Formen möglicher Erfahrung. *Zeitschrift für Tierpsychologie*, *5*, 235–409.

Matheson, H. E., and McMullen, P. A. (2011). A computer-generated face database with ratings on realism, masculinity, race, and stereotypy. *Behavior Research Methods, 43,* 224–228.

Mitteroecker, P., and Gunz, P. (2009). Advances in geometric morphometrics. *Evolutionary Biology, 36*, 235–247.

Muller, U., and Mazur, A. (1997). Facial dominance in *Homo sapiens* as honest signaling of male quality. *Behavioral Ecology, 8*, 569–579.

Oosterhof, N. N., and Todorov, A. (2008). The functional basis of face evaluation. *Proceedings of the National Academy of Sciences, 105*, 11087–11092.

Parker, G. A. (1974). Assessment strategy and the evolution of fighting behaviour. *Journal of Theoretical Biology, 47*, 223–243.

Penton-Voak, I. S., Jones, B. C., Little, A. C., Baker, S., Tiddeman, B., Burt, D. M., and Perrett, D. I. (2001). Symmetry, sexual dimorphism in facial proportions and male facial attractiveness. *Proceedings of the Royal Society B, 268*, 1617–1623.

Puts, D. A. (2010). Beauty and the beast: Mechanisms of sexual selection in humans. *Evolution and Human Behavior, 31*, 157–175.

Rantanen, T., Guralnik, J. M., Foley, D., Masaki, K., Leveille, S., Curb, J. D., and White, L. (1999). Midlife hand grip strength as a predictor of old age disability. *Journal of the American Medical Association, 28*, 558–560.

Re, D. E., DeBruine, L. M., Jones, B. C., and Perrett, D. I. (2013) Facial cues to perceived height influence leadership choices in simulated war and peace contexts. *Evolutionary Psychology, 11*, 89–103.

Rule, N. O., Ambady, N., Adams, R. B., Ozono, H., Nakashima, S., Yoshikawa, S., and Watabe, M. (2010). Polling the face: Prediction and consensus across cultures. *Journal of Personality and Social Psychology, 98*, 1–15.

Schaefer, K., Mitteroecker, P., Fink, B., and Bookstein, F. L. (2009). Psychomorphospace-From biology to perception, and back: Towards an integrated quantification of facial form variation. *Biological Theory, 4*, 98–106.

Schneider, T. M., Hecht, H., and Carbon, C. (2012). Judging body weight from faces: The height-weight illusion. *Perception, 41*, 121–124.

Sell, A., Cosmides, L., Tooby, J., Sznycer, D., Von Rueden, C., and Gurven, M. (2009). Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proceedings of the Royal Society B, 276*, 575–584.

Sell, A., Tooby, J., and Cosmides, L. (2009). Formidability and the logic of human anger. *Proceedings of the National Academy of Sciences, 106*, 15073–15078.

Smuts, B. (1987). *Primate societies*. Chicago: University of Chicago Press.

Von Rueden, C., Gurven, M., and Kaplan, H. (2008). The multiple dimensions of male social status in an Amazonian society. *Evolution and Human Behavior, 29*, 402–415.

Von Rueden, C., Gurven, M., and Kaplan, H. (2011). Why do men seek status? Fitness payoffs to dominance and prestige. *Proceedings of the Royal Society B, 278*, 2223–2232.

Wiggins, J. S. (1979). A psychological taxonomy of trait-descriptive terms: The interpersonal domain. *Journal of Personality and Social Psychology, 37*, 395–412.

Wiggins, J. S., Phillips, N., and Trapnell, P. (1989). Circular reasoning about interpersonal behavior: Evidence concerning some untested assumptions underlying diagnostic classification. *Journal of Personality and Social Psychology, 56*, 296–305.

Wind, A. E., Takken, T., Helders, P. J., and Engelbert, R. H. (2010). Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? *European Journal of Pediatrics, 30*, 477–488.

Windhager, S., Schaefer, K., and Fink, B. (2011). Geometric morphometrics of male facial shape in relation to physical strength and perceived atractiveness, dominance, and masculinity. *American Journal of Human Biology, 23,* 805–814.

Zebrowitz, L. A. (1997). *Reading faces: Window to the soul?* Boulder, CO: Westview P.

Zebrowitz, L. A., Kikuchi, M., and Fellous, J.-M. (2007). Are effects of emotion expression on trait impressions mediated by babyfaceness? Evidence from connectionist modeling. *Personality and Social Psychology Bulletin, 33*, 648–662.

Zebrowitz, L. A., and McDonald, S. M. (1991). The impact of litigants' baby-facedness and attractiveness on adjudications in small claims courts. *Law and Human Behavior, 15*, 603–623.

Zebrowitz, L. A., and Montepare, J. M. (1992). Impressions of babyfaced individuals across the life span. *Developmental Psychology, 28,* 1143–1152.

Author Note

This research was conducted with support from Fundação para a Ciência e a Tecnologia (FCT) grant SFRH/BD/75435/2010.