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Facial cues to physical strength increase attractiveness but decrease aggressiveness assessments in male Maasai of Northern Tanzania

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ABSTRACT

Male physical formidability may reflect capacities to provision and protect, resource holding potential, and social status. Handgrip strength (HGS) is a robust measure of overall muscular strength and function that correlates positively with ratings of male facial attractiveness and dominance. Here, we examine strength, attractiveness, and aggressiveness assessments as a function of facial cues to HGS in a sample of male Maasai of Northern Tanzania. Adult Maasai (56 women, 40 men) rated three strength-calibrated facial morphs of Maasai men. These morphs were constructed by performing a geometric morphometric shape regression on HGS using digital images of 54 men (20–29 years). Participants judged facial morphs calibrated to greater HGS higher on strength and attractiveness, but lower on aggressiveness. The accurate assessment of male Maasai physical strength from facial cues and the corresponding attractiveness assessments of strength cues are consistent with evolutionary predictions and previous research. The situation is less clear for the association of facial strength cues with the assessment of aggression. Future research should consider the possibility of a (feature-based) perceptual overgeneralization, especially in the interpretation of facial aggressiveness judgments, in addition to population-specific influences, and distinguish them from facial cues that indicate behavioral dispositions. Collectively, the findings of the present study corroborate the suggestion that the Maasai are sensitive to facial cues of strength and use these cues in social assessments.

1. Introduction

Natural selection shaped the criteria by which individuals attain social status (see Buss et al., 2020, for a review), and variation in status reflects individual differences in fitness-relevant domains. These include mating-related and coalitional qualities, health outcomes, and social relations, ultimately tracing conditions and behavior that correlated with ancestral reproductive success. Psychological mechanisms that evaluate male status include the assessment of physical strength. In the present study, we examined the role of physical strength (as assessed by handgrip strength; HGS) and its assessment from facial cues in a sample of young male Maasai of Northern Tanzania (see also Butovskaya et al., 2018).

Physical strength is sexually dimorphic due to the influences of androgenic hormones and fat-free body mass, suggesting that this trait has been elaborated through sexual selection (Gallup & Fink, 2018). Men are typically taller than women (Gray & Wolfe, 1980) and have more muscle mass (Bishop, Cureton, & Collins, 1987), especially in the upper body (Lassek & Gaulin, 2009). They tend to be physically stronger than women (Butovskaya et al., 2018, for the Maasai; Guenther, Buerger, Rickert, Crispin, & Schulz, 2008, for Germany), also after controlling for the influences of body height and weight (Miller, MacDougall, Tarnopolsky, & Sale, 1993; Musselman & Brouwer, 2005). Individuals with greater HGS, both men and women, have a greater life

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expectancy (Kim & Ho, 2020). Physical strength and upper body size may augment male mating success by increasing other men's dominance perceptions, rather than by increasing female-judged sexual attractiveness (Kordsmeyer, Hunt, Puts, Ostner, & Penke, 2018).

By provisioning through large-game hunting (see Apicella, 2014), but also by coalitional aggression (with the resulting need for coalitional defense of women and land/resources), ancestral males may have enhanced their reproductive success. On a theoretical level (Trivers, 1972), along with results from recent meta-analyses (Buss et al., 2020; von Rueden & Jaeggi, 2016), male-specific status criteria center on specific components such as athleticism, bravery, physical formidability, and aspects of leadership. Among the status criteria shared by men and women is health, in addition to having children, group and social value, and kin alliances (Buss et al., 2020). Physical strength can serve as a proxy at least for athleticism, physical formidability, and health.

Humans can reliably discriminate weaker from stronger (unfamiliar) individuals from viewing bodily and/or facial images (Han et al., 2017; Holzleitner & Perrett, 2016; Sell et al., 2009). For large-scale, urban, Western industrialized populations, research demonstrates theory-consistent evidence of a moderate positive relationship between male physical strength and facial ratings of dominance or masculinity (Fink, Neave, & Seydel, 2007; Gallup, O'Brien, White, & Wilson, 2010) and attractiveness (Fink et al., 2007; Shoup & Gallup, 2008). Conceptually, via the action of testosterone (Batrinos, 2012), "[...] masculinity may signal both (desirable) immunity and (potentially costly) aggression in humans" (Scott et al., 2014, p. 14388). On a population level, the outcome of this trade-off may vary as a function of the environment.

Some research reports a positive association between male physical strength and (perceived) aggressiveness (i.e., the quality of being likely to attack other people or animals or to behave violently or angrily towards them; Cambridge Dictionary, 2021), attributed to higher testosterone levels in stronger men (reviewed in Gallup & Fink, 2018). A study of adolescent boys from upstate New York showed a positive association between physical strength and perceived aggressiveness from facial cues (Gallup et al., 2010). Such associations might, however, be modulated by environmental factors: Scott et al. (2014) showed that increased masculinity was associated with opposite-sex-rated aggressiveness in industrialized, urbanized populations (i.e. low disease, fertility, and homicide rates), but not in populations that score lower on the human development index and have more traditional lifestyles (e.g., foraging, pastoralism, hunting, horticulture). Other research reported a negative association between male physical strength and aggressiveness linking physical weakness to unstable personality (Fink, Weege, Pham, & Shackelford, 2016, for neuroticism). At the proximate level, physical strength and aggressive-antisocial traits are mediated by changing hormone levels during development, suggesting adaptive congruence between male-typical behavioral dispositions and physical masculinization during puberty (Isen, McGue, & Iacono, 2015). Ultimate explanations of the strength-aggressiveness relationship assume utility in the use of alternative strategies to obtain status when physical dominance is not an option, i.e., higher aggression to compensate for physical disadvantage in resource competitions (Knapen, Blaker, & Van Vugt, 2018). Finally, some research finds no association between male physical strength and aggressiveness (Archer & Thanzami, 2009, for self-reports). In a study of Canadian undergraduates, Carré, McCormick, and Mondloch (2009) identified a positive correlation between male aggressiveness in a laboratory task and perceived aggressiveness from neutral photographs as well as between the same aggressiveness score and a measure of facial shape (i.e., fWHR: upper lip to mid-brow divided by bizygomatic width). Ratings of aggression were negatively correlated with attractiveness assessments.

The majority of studies on assessments of facial cues to physical strength have been conducted in industrialized societies. Thus, it is unclear whether members of pre-industrialized societies would judge facial strength cues similarly to what has been reported from samples of industrialized societies. Apicella (2014) showed that in male Hadza hunter-gatherers, upper-body strength correlates with hunting reputation and reproductive success. However, this study did not investigate whether the information about male physical strength can be assessed from facial cues. The face provides important information in social interaction (Leopold & Rhodes, 2010; Little, Jones, & DeBruine, 2011) and some evidence suggests that psychological mechanisms for the assessment of physical strength from faces (and bodies) may be universal (Sell et al., 2009). Recent research, however, on Maasai perceptions of physical strength from gait (of British men) argued against a universal perception of physical strength from gait information (Fink, Butovskaya, & Shackelford, 2019). Whether this finding suggests that such information is less important in the Maasai than in other societies, or if the finding is limited to dynamic representations of the human body (as opposed to static facial/bodily cues), is unclear. Butovskaya et al. (2018) reported that the patterns of relationships between physical strength and facial shape in the Maasai are similar to those reported from investigations in samples from industrialized societies. However, these authors did not secure facial assessments, thus leaving open the question about perceptions of strength from facial cues. The present study extends previous research by restricting variation in the stimuli to shape correlates of physical strength (as indexed by HGS). This calibration takes advantage of geometric morphometric morphs that preclude rating biases accompanying assessments of individuals of known identity (Windhager et al., 2018).

The current study was conducted among the Maasai pastoralists of the Ngorongoro Conservation Area (Butovskaya & Butovsky, 2017) as part of a long-term project led by one of us (MLB), investigating the biological and cultural characteristics of pre-industrial societies in Tanzania. According to their lifestyle, physical strength is highly valued and an important component of status and reputation for young men. An age-based social system places these men in the group of *murans* ("junior warriors"), whose tasks are to protect cattle and local households from carnivores and raids of neighboring tribes (e.g., Datoga, Sukuma) as well as stealing cattle from them (Butovskaya & Butovsky, 2017).

Conceptually embedded in the "young male syndrome" (Wilson & Daly, 1985) and the "discrepancy stress" phenomenon (Reidy, Berke, Gentile, & Zeichner, 2014), male physical strength is an ideal determinant for perceptions of attractiveness and aggressiveness in the context of the pursuit of status in Maasai junior warriors. The young male syndrome refers to the greater tendency of young men to be more risk-oriented and aggressive than other demographic groups (Baker, 2012). This is attributed to the increased intensity of male competition because of asymmetric obligatory parental investment (Trivers, 1972) and greater reproductive variance among men than women. Thus, men who were most fierce and dominant would have gained access to more mating opportunities than men who were submissive or noncompetitive (Baker, 2012). Less formidable men, in turn, may be pressured towards greater aggressiveness as an alternative strategy to attain status and gain access to mating partners (Knapen et al., 2018). Relatedly, the psychological literature includes reference to "male discrepancy stress" (i.e., perceiving oneself as less than average in masculinity) and has linked increased discrepancy stress to greater aggressiveness and sexual as well as non-sexual violence (Reidy et al., 2014).

Murans are perceived as more aggressive than older men, more ready to quarrel with everyone, and more sexually harassing of women (pers. communication M. L. Butovskaya 2021, field interviews). This renders murans an optimal sample to investigate the interrelations among perceptions of physical strength, attractiveness, and aggressiveness. We reported previously (Butovskaya et al., 2018) that physically stronger male Maasai have wider faces, a lower and broader forehead, wider eyebrows, and an overall appearance judged to be more robust. In the present study, we investigated strength, attractiveness, and aggressiveness assessments as a function of physical strength encoded in facial shape. We hypothesized that Maasai men and women would judge facial morphs of young adult male Maasai that depict greater physical strength

as stronger and more attractive than those depicting lesser physical strength. Due to the scarcity of quantitative evidence, the study of the relationship between male physical strength and perceived aggressiveness was framed as exploratory.

2. Material and methods

2.1. Facial stimuli

The current study used calibrated facial morphs that were created and described in Butovskaya et al. (2018). In brief, stimuli images were based on standardized facial photographs and measurements of HGS (a proxy for physical strength: e.g., Rantanen et al., 1999; Wind, Takken, Helders, & Engelbert, 2010) of 54 men (20–29 years) recruited from the pastoralist population of the Maasai of Endulen in the Ngorongoro Conservation Area, Tanzania (see Århem, 1985, and Saitoti & Beckwith, 1980, for population characteristics). The shape of the face was captured by 71 landmarks and semilandmarks, subjected to a Generalized Procrustes superimposition (Bookstein, 1991), and symmetrized (Mardia, Bookstein, & Moreton, 2000; Mitteroecker & Gunz, 2009). From the subsequent geometric morphometric shape regression on HGS, landmark coordinates of three facial target configurations were computed: sample average ("average"), average − 5 standard deviations ("low"), and + 5 standard deviations ("high") (see Fig. 1, and Butovskaya et al., 2018). The original photographs were then unwarped to these target configurations and averaged (Rohlf, 2015).

2.2. Face ratings

The face ratings were collected in 2017 in the same population from which the facial images were secured, the Endulen settlement from the Ngorongoro Conservation area. Because Endulen is located off the main touristic roads, the local Maasai are not in close contact with tourists and have not been acquainted with Europeans. Most of the respondents reported never visiting a school or moving out of the Ngorongoro area. The sample was composed of 96 raters, ages 16–76 years (<20 years [7 male, 9 female], 20–29 years [10 male, 24 female], 30–50 years [14 male, 17 female], >50 years [9 male, 6 female]). Participants rated each of the three stimuli images for physical strength, attractiveness, and aggressiveness (with attributes in blocks) on a 3-point Likert-type scale with response options 1 = *not at all*, 2 = *medium*, and 3 = *highly*, in response to the question "How strong/attractive/aggressive is this person"? The order of blocks was randomized, as was the sequence of stimuli within each block. Each participant completed the ratings privately. Participation was voluntary and could be ended at any time. All relevant data are available from figshare (DOI: https://doi.org/10.6084/m9.figshare.1512893.

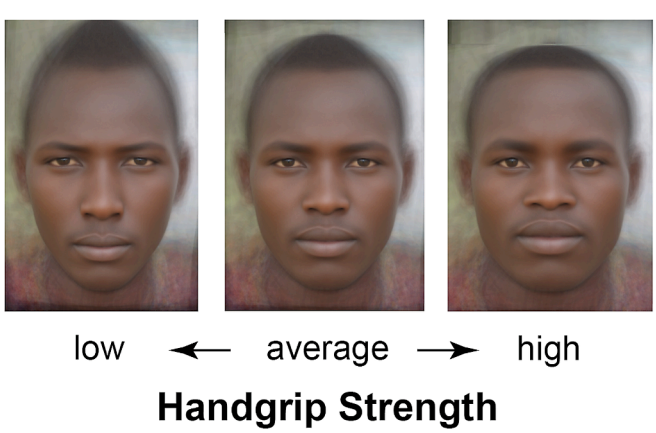

Fig. 1. The three handgrip strength (HGS)-calibrated stimuli. The facial configurations correspond to the sample average ("average") of HGS as well as to − 5 ("low") and + 5 ("high") standard deviations from that average.

2.3. Statistical analysis

The association between facial correlates of HGS and attributions of physical strength, attractiveness, and aggressiveness, respectively, were examined by Friedman and post-hoc Wilcoxon signed-rank tests. For the latter, the effect size r was calculated as ABS(Z)/SQRT(2*n). Kruskal-Wallis tests and Mann-Whitney U tests were computed to compare the genders and the four age groups. All reported p-values are uncorrected and two-tailed. IBM SPSS Statistics Version 25 was used for all analyses.

3. Results

Participants attributed greater strength to facial morphs calibrated to greater HGS (Fig. 2, Table 1). In absolute terms, none of the morphs was considered weak ($Mdn = 1$) with the lowest ratings corresponding to intermediate strength ($Mdn = 2$). Attractiveness assessments increased with greater HGS (Fig. 2, Table 1) and this differentiation was more pronounced than for strength assessments. The morph that represented low HGS received a $Mdn = 1$ (Fig. 2), corresponding to low attractiveness. The average morph had a $Mdn = 2$. The morph reflecting the highest HGS was associated with a $Mdn = 3$, with the first and third quartiles also associated with $Mdn = 3$. An opposite pattern was found for aggressiveness: Maasai attributed greater aggressiveness ($Mdn = 3$) to low HGS than to higher HGS ($Mdn = 2$ and 1, respectively; Fig. 2). Effect sizes of *post-hoc* pairwise comparisons ranged 0.35–0.60 (see Table 1). The assessments of strength, attractiveness, and aggressiveness of the facial morphs were not affected by the raters' gender or age (all $ps > 0.10$; see Table 2).

4. Discussion

The present study secured face assessments of male Maasai of Northern Tanzania and produced corroborative evidence that humans can accurately assess male physical strength from static facial cues (Han et al., 2017; Holzleitner & Perrett, 2016; Sell et al., 2009). The morphometric techniques used in the current study allowed us to isolate, quantify, and plot the facial shape changes associated with physical strength (as indexed by HGS), affording assessments of stimuli varying only in strength-related facial cues. Facial morphs associated with the greater HGS were judged to be stronger than those calibrated to average or lesser HGS. A similar association was found for attractiveness ratings of these morphs. However, aggressiveness assessments of facial morphs showed a negative association, i.e. faces corresponding to lesser or average HGS were judged higher in aggressiveness than those corresponding to higher HGS. Collectively, these results suggest that Maasai men and women are sensitive to facial cues of physical strength and use these cues in social assessments.

Physically strong men, at least in industrialized societies, are judged more likely to attain high status within social organizations, even when physical formidability is not immediately relevant (Lukaszewski, Simmons, Anderson, & Roney, 2016). Sell, Lukazsweski, and Townsley (2017) reported that estimates of physical strength accounted for 70% of male bodily attractiveness, with a linear relationship between strength and attractiveness (US stimuli assessed by Australian and US raters). A positive linear relationship also was reported for women's attractiveness assessments of male facial photographs of young German men and HGS (Fink et al., 2007), with physically stronger men judged more attractive. Archer and Thanzami (2009) reported a small positive correlation ($r = 0.22$) between right HGS and self-reported mate value in Indian (Mizo) men. Frederick and Haselton (2007) reported for a US sample that above-average male muscularity is judged more attractive than low or high muscularity (i.e. a U-shaped relationship). In the present study, we found a positive linear relationship between strength assessments and facial attractiveness in male Maasai, suggesting that

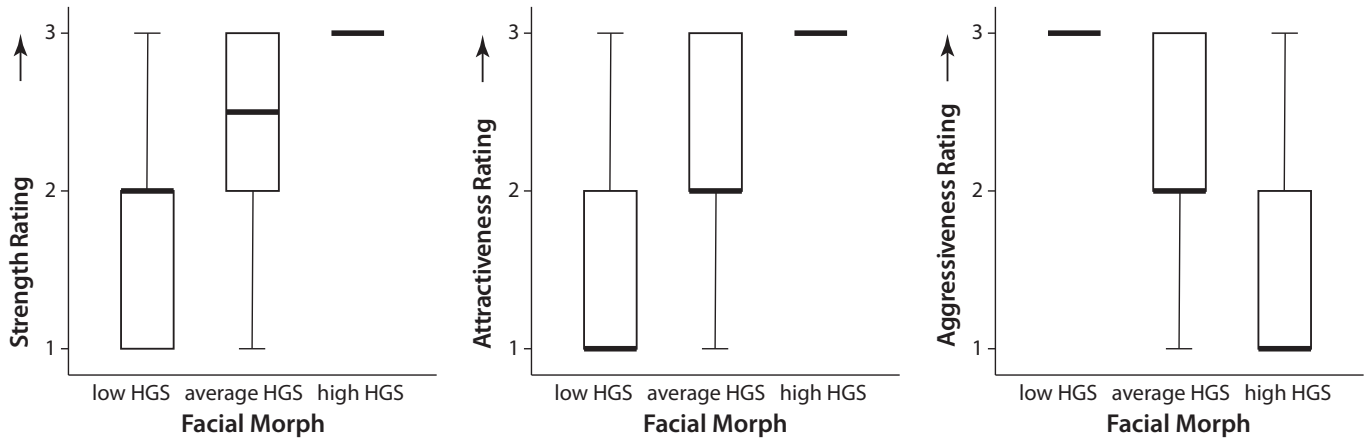

Fig. 2. Assessments of handgrip strength (HGS)-calibrated facial morphs. Box plots depict Maasai ratings of facial morphs corresponding to the sample average of HGS as well as to − 5 SD ("low HGS") and + 5 SD ("high HGS") from that average, excluding statistical outliers. Larger numbers indicate higher attributions. All pairwise comparisons between the morphs were statistically significant (see Table 1).

Table 1
Friedman-tests (and post-hoc Wilcoxon tests) for the comparison of assessments of facial morphs calibrated to handgrip strength (HGS) in male Maasai. The percentages of participants rating one morph lower, equal to, or higher than the other morph are rounded to the nearest integer. *P*-values are two-tailed and uncorrected.

Ratings of Physical Strength, Friedman Chi-Square = 95.4, $p < 0.001$, $n = 96$					
Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)
low HGS < average HGS	53	high HGS < average HGS	4	high HGS > low HGS	77
low HGS = average HGS	42	high HGS = average HGS	53	high HGS = low HGS	19
low HGS > average HGS	5	high HGS > average HGS	43	high HGS < low HGS	4
Test statistics	$Z = -5.615$, $p < 0.001$	Test statistics	$Z = -4.838$, $p < 0.001$	Test statistics	$Z = -7.308$, $p < 0.001$
Effect size	$r = 0.41$	Effect size	$r = 0.35$	Effect size	$r = 0.53$
Ratings of Attractiveness, Friedman Chi-Square = 132.7, $p < 0.001$, $n = 96$					
Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)
low HGS < average HGS	73	high HGS < average HGS	3	high HGS > low HGS	92
low HGS = average HGS	25	high HGS = average HGS	50	high HGS = low HGS	5
low HGS > average HGS	2	high HGS > average HGS	47	high HGS < low HGS	3
Test statistics	$Z = -7.396$, $p < 0.001$	Test statistics	$Z = -5.599$, $p < 0.001$	Test statistics	$Z = -8.398$, $p < 0.001$
Effect size	$r = 0.53$	Effect size	$r = 0.40$	Effect size	$r = 0.60$
Ratings of Aggressiveness, Friedman Chi-Square = 72.0, $p < 0.001$, $n = 96$					
Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)	Comparison Morphs	Respondents (%)
low HGS < average HGS	9	high HGS < average HGS	64	high HGS > low HGS	14
low HGS = average HGS	42	high HGS = average HGS	23	high HGS = low HGS	7
low HGS > average HGS	49	high HGS > average HGS	14	high HGS < low HGS	79
Test statistics	$Z = -4.887$, $p < 0.001$	Test statistics	$Z = -6.172$, $p < 0.001$	Test statistics	$Z = -7.598$, $p < 0.001$
Effect size	$r = 0.35$	Effect size	$r = 0.45$	Effect size	$r = 0.55$

Table 2
Comparisons of handgrip strength (HGS) calibrated face ratings (separately for the three facial morphs) regarding gender (a) and age group (b). Table 2a reports Mann-Whitney *U* tests, and Table 2b reports Kruskal-Wallis tests with *p*-values two-tailed and uncorrected.

a) Gender	*Ratings*								
	Strength			Attractiveness			Aggressiveness		
Facial Morph	*U*	*p*	*n*	*U*	*p*	*n*	*U*	*p*	*n*
low HGS	1004	0.347	96	1112	0.935	96	1101	0.835	96
average HGS	928	0.106	96	1105	0.900	96	1049	0.552	96
high HGS	1072	0.534	96	1055	0.313	96	1084	0.938	96

b) Age groups	*Ratings*								
	Strength			Attractiveness			Aggressiveness		
Facial Morph	*H*	*p*	*n*	*H*	*p*	*n*	*H*	*p*	*n*
low HGS	2.706	0.439	96	2.282	0.516	96	5.703	0.127	96
average HGS	2.813	0.421	96	5.148	0.161	96	0.566	0.904	96
high HGS	1.224	0.747	96	1.784	0.618	96	2.818	0.410	96

facial cues to male physical strength are judged positively by both male and female Maasai assessors – similar to findings in samples from industrialized societies (e.g., Fink et al., 2007; Sell et al., 2017). A replication of the current findings could use a larger number of strength-calibrated facial morphs to investigate possible differences between Western samples and those from other societies in the type of relationship (e.g., linear vs. (a)symmetrically U-shaped; see Windhager et al., 2018) between facial cues to physical strength and attractiveness.

Regarding the assessment of male aggressiveness from facial cues to physical strength, our interpretation of the negative relationship between facial cues to strength and aggressiveness judgments is less definite. Related research suggests that the faces of physically strong men are judged higher on aggressiveness. For example, several studies have documented a positive relationship between HGS and self-reported aggression (reviewed in Gallup & Fink, 2018), and one study (Gallup et al., 2010) reported a positive association between HGS and perceived aggressiveness ($r = 0.30$) using facial stimuli. These findings contrast with those of the present study. Possible explanations for the current results include i) aggressiveness as a facultative behavioral strategy and ii) feature-based perceptual overgeneralization of aggressiveness from facial strength cues (see Oosterhof & Todorov, 2008).

In our study, HGS of male Maasai correlated positively with body height ($r_s = 0.23$, $p = 0.05$, $n = 54$). This relationship also held for the total male sample with a larger age range (17–90 years, $rs = 0.27$, $p < 0.001$, $n = 181$, Butovskaya et al., 2018). Stronger individuals tend to be taller – and body height correlates with male competitiveness, physical formidability, and status (Puts, 2010). Weaker (and shorter) men, however, may feel pressure from the challenge to compete effectively with other men, leading to greater aggressiveness as a facultative behavioral strategy to attain status and thus gain access to mating partners. Knapen et al. (2018) reported that in dyadic intrasexual competitions with taller rivals, shorter men compensated for height differences by behaving more aggressively. Thus, greater aggressiveness may be motivated by "discrepancy stress" – the self-perception of deficient masculinity (Reidy et al., 2014). For example, North American men who reported "that others perceive them to be less masculine than the 'average' man" were more likely to commit violent assaults (Reidy, Berke, Gentile, & Zeichner, 2016). Greater impulsive aggression is positively associated with neuroticism (Gauthier, Furr, Mathias, Marsh-Richard, & Dougherty, 2009), which correlates negatively with physical strength (Fink et al., 2016). The finding of the present study suggests that facial cues to male physical strength may portend aggression, especially in men who use aggression as a facultative behavioral strategy to achieve status.

Research on visual assessments of physical strength from facial cues suggests that these assessments are accurate (Sell et al., 2009). However, certain facial features or facial configurations can lead to perceptual overgeneralization in impression formation (Hess, Adams, & Kleck, 2009; Oosterhof & Todorov, 2008; Zebrowitz, 2018). From this perspective, a face never looks "neutral," but impressions are formed due to the specific shape, size, and arrangement of features (Zebrowitz & Collins, 1997; Zebrowitz & Montepare, 2008). There are structural similarities between the facial correlates of low physical strength and the facial expression of anger: lowered brows accompany an angry frown, for example (Brannigan & Humphries, 1972). These similarities may cause an increase in perceived aggressiveness (Třebický, Havlíček, Roberts, Little, & Kleisner, 2013). How strong this effect may have been in the present study is unclear. Similarly, we cannot rule out the possibility that facial cues to greater strength produce an *attractiveness halo* (Dion, Berscheid, & Walster, 1972), with physically strong and attractive male faces judged less aggressive.

Regarding Maasai culture-specific effects of face assessments, the age-set system may be most notable (for a detailed description of Maasai cultural characteristics, see Århem, 1985; Butovskaya et al., 2018). Political and social life in the Maasai is built on male age-sets for which recruitment and promotion are based on chronological age. Each age-set requires individuals to perform certain duties, follow specific behavioral norms, and entitles privileges exclusive to that age-set (Morton, 1979). The age-set contributing stimuli for the current study was 20–29 years old, which places these men in the group of *il murran* ("junior warriors") who live together in a separate locality. For unmarried girls, these men can be friends, protectors, and lovers, but some of these men also may be "vicious with girls or of bad character" (Spencer, 2004, Kindle location 2779, p. 113). In this view, the positive association between facial cues to physical strength and attractiveness and the negative associations between strength/attractiveness and perceived aggressiveness appear reasonable. Further support comes from informal interviews with local representatives of the Maasai during fieldwork (pers. communication, M. L. Butovskaya, 2021): Physically strong men are treated with respect and are expected to be helpful to members of the community. Weaker young men are usually more hostile and can easily get angry. Also, women commented that they tend to stay away from such young men and dislike them.

When male Maasai enter the next age-set, they cease to be *il murran* and become junior elders. Whether the transition from one age-set to another affects strength, attractiveness, and aggressiveness assessments of male faces cannot be answered by the present cross-sectional study, which secured single assessments of young male Maasai. In addition, long-term developmental and life-history studies could investigate the extent to which variation in formidability in young adulthood contributes to individual reproduction and social reputation in later life.

Given that the current study was intra-cultural, it remains to be determined whether the observed assessments generalize to rater populations unfamiliar with the Maasai. Research has shown that faces from unfamiliar populations are more difficult to discern than faces of one's own population (Fu, Hu, Wang, Quinn, & Lee, 2012; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005; Wheeler et al., 2011). Whether such effects are relevant to trait attribution related to physical strength is unknown. Thus, future studies should consider systematic variations of both stimuli and raters to address these issues.

Understanding how impressions are formed based on facial features is of theoretical and practical interest in the cognitive sciences, evolutionary biology, anthropology, and psychology. Building a comprehensive analytical framework for understanding why and how we attribute social traits to faces within and across cultures is of special importance given the increasingly popular use of facial displays in social media displays. The present study presents findings on facial feature-based impression formation in a non-industrialized society, the Maasai of Northern Tanzania. Calibrating facial morphology to HGS allowed the investigation of strength, attractiveness, and aggressiveness assessments based only on facial cues of physical strength. Our results do not support the hypothesis of a positive association between strength and perceived aggressiveness but are consistent with the concept of aggression as a facultative behavioral strategy to achieve status by compensating for relative physical weakness in young men. Future efforts to identify universal vs. society-specific assessments of facial morphology should secure crosswise face assessments from different populations. This may be particularly important for the interpretation of findings from non-industrialized societies when comparing them with findings from previous investigations of Western samples.

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Author contributions

MLB and BF conceptualized the study. MLB collected facial

photographs. SW created the stimuli images. MLB collected the rating data. AME, MLB, BF, KS, and SW analyzed the data. AMA managed local administration. All authors contributed to the interpretation and manuscript preparation. All authors revised the article critically for intellectual content and approved the submitted version.

Ethics statement

Ethical approval of the study was obtained from the ethical committee at Moscow State University (protocol #55, 2015) and the Tanzania Commission for Science and Technology (protocols #2015-117-ER-2009-151 and #2017-185-NA-2009-151), and the Ngorongoro Conservation Area administration. Informed consent was obtained from all participants, either in written or verbal form.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Apicella, C. L. (2014). Upper-body strength predicts hunting reputation and reproductive success in Hadza hunter–gatherers. *Evolution and Human Behavior, 35*(6), 508–518. https://doi.org/10.1016/j.evolhumbehav.2014.07.001

Archer, J., & Thanzami, V. (2009). The relation between mate value, entitlement, physical aggression, size and strength among a sample of young Indian men. *Evolution and Human Behavior, 30*, 315–321. https://doi.org/10.1016/j.evolhumbehav.2009.03.003

Århem, K. (1985). *Pastoral man in the garden of Eden: The Maasai of the Ngorongoro conservation area, Tanzania*. Uppsala: University of Uppsala, Department of Cultural Anthropology in cooperation with The Scandinavian Institute of African Studies, Uppsala.

Baker, M. D. (2012). Risk-taking behavior (young male syndrome). In V. S. Ramachandran (Ed.), *Encyclopedia of human behavior* (2nd ed., pp. 276–279). Academic Press. https://doi.org/10.1016/B978-0-12-375000-6.00307-4.

Batrinos, M. L. L. (2012). Testosterone and aggressive behavior in man. *International Journal of Endocrinology & Metabolism, 10*(3), 563–568. https://doi.org/10.5812/ijem.3661

Bishop, P., Cureton, K., & Collins, M. (1987). Sex difference in muscular strength in equally-trained men and women. *Ergonomics, 30*(4), 675–687. https://doi.org/10.1080/00140138708969760

Bookstein, F. L. (1991). *Morphometric tools for landmark data: Geometry and biology*. New York: Cambridge University Press.

Brannigan, C. R., & Humphries, D. A. (1972). Human non-verbal behaviour, a means of communication. In N. G. Blurton Jones (Ed.), *Ethological studies of child behaviour* (pp. 37–64). London: Cambridge University Press.

Buss, D. M., Durkee, P. K., Shackelford, T. K., Bowdle, B. F., Schmitt, D. P., Brase, G. L., … Trofimova, I. (2020). Human status criteria: Sex differences and similarities across 14 nations. *Journal of Personality and Social Psychology: Attitudes and Social Cognition, 119*(5), 979–998. https://doi.org/10.1037/pspa0000206

Butovskaya, M. L., & Butovsky, R. O. (2017). Maasai of Tanzania: The problems of sustainable development on the territory of Ngorongoro conservation area. *Siberian Historical Research, 3*, 221–250. https://doi.org/10.17223/2312461X/17/12

Butovskaya, M. L., Windhager, S., Karelin, D., Mezentseva, A., Schaefer, K., & Fink, B. (2018). Associations of physical strength with facial shape in an African pastoralist society, the Maasai of Northern Tanzania. *PLoS One, 13*(5), Article e0197738. https://doi.org/10.1371/journal.pone.0197738

Cambridge Dictionary. (2021). Aggressiveness. Retrieved November 11, 2020, from https://dictionary.cambridge.org/dictionary/english/aggressiveness.

Carré, J. M., McCormick, C. M., & Mondloch, C. J. (2009). Facial structure is a reliable cue of aggressive behavior. *Psychological Science, 20*(10), 1194–1198. https://doi.org/10.1111/j.1467-9280.2009.02423.x

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology, 24*(3), 285–290. https://doi.org/10.1037/h0033731

Fink, B., Butovskaya, M. L., & Shackelford, T. K. (2019). Assessment of physical strength from gait: Data from the Maasai of Tanzania. *Biology Letters, 15*(3), 20180803. https://doi.org/10.1098/rsbl.2018.0803

Fink, B., Neave, N., & Seydel, H. (2007). Male facial appearance signals physical strength to women. *American Journal of Human Biology, 19*(1), 82–87. https://doi.org/10.1002/ajhb.20583

Fink, B., Weege, B., Pham, M. N., & Shackelford, T. K. (2016). Handgrip strength and the big five personality factors in men and women. *Personality and Individual Differences, 88*, 175–177. https://doi.org/10.1016/j.paid.2015.09.013

Frederick, D. A., & Haselton, M. G. (2007). Why is muscularity sexy? Tests of the fitness indicator hypothesis. *Personality and Social Psychology Bulletin, 33*(8), 1167–1183. https://doi.org/10.1177/0146167207303022

Fu, G., Hu, C. S., Wang, Q., Quinn, P. C., & Lee, K. (2012). Adults scan own- and other-race faces differently. *PLoS One, 7*(6), Article e37688. https://doi.org/10.1371/journal.pone.0037688

Gallup, A. C., & Fink, B. (2018). Handgrip strength as a Darwinian fitness indicator in men. *Frontiers in Psychology, 9*, 439. https://doi.org/10.3389/fpsyg.2018.00439

Gallup, A. C., O'Brien, D. T., White, D. D., & Wilson, D. S. (2010). Handgrip strength and socially dominant behavior in male adolescents. *Evolutionary Psychology, 8*(2), 229–243. https://doi.org/10.1177/147470491000800207

Gauthier, K. J., Furr, R. M., Mathias, C. W., Marsh-Richard, D. M., & Dougherty, D. M. (2009). Differentiating impulsive and premeditated aggression: Self and informant perspectives among adolescents with personality pathology. *Journal of Personality Disorders, 23*(1), 76–84. https://doi.org/10.1521/pedi.2009.23.1.76

Gray, J. P., & Wolfe, L. D. (1980). Height and sexual dimorphism of stature among human societies. *American Journal of Physical Anthropology, 53*(3), 441–456. https://doi.org/10.1002/ajpa.1330530314

Guenther, C. M., Buerger, A., Rickert, M., Crispin, A., & Schulz, C. U. (2008). Grip strength in healthy Caucasian adults: Reference values. *The Journal of Hand Surgery, 33*(4), 558–565. https://doi.org/10.1016/j.jhsa.2008.01.008

Han, C., Kandrik, M., Hahn, A. C., Fisher, C. I., Feinberg, D. R., Holzleitner, I. J., … Jones, B. C. (2017). Interrelationships among men's threat potential, facial dominance, and vocal dominance. *Evolutionary Psychology, 15*(1). https://doi.org/10.1177/1474704917697332

Hess, U., Adams, R. B., & Kleck, R. E. (2009). The face is not an empty canvas: How facial expressions interact with facial appearance. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 364*(1535), 3497–3504. https://doi.org/10.1098/rstb.2009.0165

Holzleitner, I. J., & Perrett, D. I. (2016). Perception of strength from 3D faces is linked to facial cues of physique. *Evolution and Human Behavior, 37*(3), 217–229. https://doi.org/10.1016/j.evolhumbehav.2015.11.004

Isen, J. D., McGue, M. K., & Iacono, W. G. (2015). Aggressive-antisocial boys develop into physically strong young men. *Psychological Science, 26*(4), 444–455. https://doi.org/10.1177/0956797614567718

Kim, K., & Ho, J. H. (2020). Handgrip strength and mortality in elderly Koreans: Evidence from the Korea longitudinal study of ageing. *Asia-Pacific Journal of Public Health, 32*(6–7), 302–309. https://doi.org/10.1177/1010539520937100

Knapen, J. E. P., Blaker, N. M., & Van Vugt, M. (2018). The Napoleon complex: When shorter men take more. *Psychological Science, 29*(7), 1134–1144. https://doi.org/10.1177/0956797618772822

Kordsmeyer, T. L., Hunt, J., Puts, D. A., Ostner, J., & Penke, L. (2018). The relative importance of intra- and intersexual selection on human male sexually dimorphic traits. *Evolution and Human Behavior, 39*(4), 424–436. https://doi.org/10.1016/j.evolhumbehav.2018.03.008

Lassek, W. D., & Gaulin, S. J. C. (2009). Costs and benefits of fat-free muscle mass in men: Relationship to mating success, dietary requirements, and native immunity. *Evolution and Human Behavior, 30*, 322–328. https://doi.org/10.1016/j.evolhumbehav.2009.04.002

Leopold, D. A., & Rhodes, G. (2010). A comparative view of face perception. *Journal of Comparative Psychology, 124*(3), 233–251. https://doi.org/10.1037/a0019460

Little, A. C., Jones, B. C., & DeBruine, L. M. (2011). The many faces of research on face perception. *Philosophical Transactions of the Royal Society B, 366*, 1634–1637. https://doi.org/10.1098/rstb.2010.0386

Lukaszewski, A. W., Simmons, Z. L., Anderson, C., & Roney, J. R. (2016). The role of physical formidability in human social status allocation. *Journal of Personality and Social Psychology, 110*(3), 385–406. https://doi.org/10.1037/pspi0000042

Mardia, K. V., Bookstein, F. L., & Moreton, I. J. (2000). Statistical assessment of bilateral symmetry of shapes. *Biometrika, 87*(2), 285–300. https://doi.org/10.1093/biomet/87.2.285

Miller, A., MacDougall, J., Tarnopolsky, M., & Sale, D. (1993). Gender differences in strength and muscle fiber characteristics. *European Journal of Applied Physiology and Occupational Physiology, 66*, 254–262. https://doi.org/10.1007/BF00235103

Mitteroecker, P., & Gunz, P. (2009). Advances in geometric morphometrics. *Evolutionary Biology, 36*(2), 235–247. https://doi.org/10.1007/s11692-009-9055-x

Morton, F. (1979). The structure of east African age-set systems. *PULA: Botswana Journal of African Studies, 1*(2), 77–102. retrieved from http://digital.lib.msu.edu/projects/africanjournals/html/itemdetail.cfm?recordID=2415.

Musselman, K., & Brouwer, B. (2005). Gender-related differences in physical performance among seniors. *Journal of Aging and Physical Activity, 13*(3), 239–253. https://doi.org/10.1123/japa.13.3.239

Oosterhof, N. N., & Todorov, A. (2008). The functional basis of face evaluation. *Proceedings of the National Academy of Sciences USA, 105*(32), 11087–11092. https://doi.org/10.1073/pnas.0805664105

Puts, D. A. (2010). Beauty and the beast: Mechanisms of sexual selection in humans. *Evolution and Human Behavior, 31*(3), 157–175. https://doi.org/10.1016/j.evolhumbehav.2010.02.005

Rantanen, T., Guralnik, J. M., Foley, D., Masaki, K., Leveille, S., Curb, J. D., & White, L. (1999). Midlife hand grip strength as a predictor of old age disability. *Journal of the*

American Medical Association, 281(6), 558–560. https://doi.org/10.1001/jama.281.6.558

Reidy, D. E., Berke, D. S., Gentile, B., & Zeichner, A. (2014). Man enough? Masculine discrepancy stress and intimate partner violence. *Personality and Individual Differences, 68*, 160–164. https://doi.org/10.1016/j.paid.2014.04.021

Reidy, D. E., Berke, D. S., Gentile, B., & Zeichner, A. (2016). Masculine discrepancy stress, substance use, assault and injury in a survey of US men. *Injury Prevention, 22*(5), 370–374. https://doi.org/10.1136/injuryprev-2015-041599

Rohlf, F. J. (2015). The tps series of software. *Hystrix, 26*(1), 9–12. https://doi.org/10.4404/hystrix-26.1-11264

von Rueden, C. R., & Jaeggi, A. V. (2016). Men's status and reproductive success in 33 nonindustrial societies: Effects of subsistence, marriage system, and reproductive strategy. *Proceedings of the National Academy of Sciences, 113*(39), 10824–10829. https://doi.org/10.1073/pnas.1606800113

Saitoti, T. O., & Beckwith, C. (1980). *Maasai.* New York: Abradale Press.

Sangrigoli, S., Pallier, C., Argenti, A.-M., Ventureyra, V. A. G., & de Schonen, S. (2005). Reversibility of the other-race effect in face recognition during childhood. *Psychological Science, 16*(6), 440–444. https://doi.org/10.1111/j.0956-7976.2005.01554.x

Scott, I. M., Clark, A. P., Josephson, S. C., Boyette, A. H., Cuthill, I. C., Fried, R. L., … Penton-Voak, I. S. (2014). Human preferences for sexually dimorphic faces may be evolutionarily novel. *Proceedings of the National Academy of Sciences USA, 111*(40), 14388–14393. https://doi.org/10.1073/pnas.1409643111

Sell, A., Cosmides, L., Tooby, J., Sznycer, D., Von Rueden, C., & 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: Biological Sciences, 276*(1656), 575–584. https://doi.org/10.1098/rspb.2008.1177

Sell, A., Lukazsweski, A. W., & Townsley, M. (2017). Cues of upper body strength account for most of the variance in men's bodily attractiveness. *Proceedings of the Royal Society B: Biological Sciences, 284*(1869), 20171819. https://doi.org/10.1098/rspb.2017.1819

Shoup, M. L., & Gallup, G. G. (2008). Men's faces convey information about their bodies and their behavior: What you see is what you get. *Evolutionary Psychology, 6*(3). https://doi.org/10.1177/147470490800600311, 147470490800600320.

Spencer, P. (2004). *The Maasai of Matapo* (2nd ed.). London: Routledge.

Třebický, V., Havlíček, J., Roberts, S. C., Little, A. C., & Kleisner, K. (2013). Perceived aggressiveness predicts fighting performance in mixed-martial-arts fighters. *Psychological Science, 24*(9), 1664–1672. https://doi.org/10.1177/0956797613477117

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 1871–1971). Chicago: Aldine.

Wheeler, A., Anzures, G., Quinn, P. C., Pascalis, O., Omrin, D. S., & Lee, K. (2011). Caucasian infants scan own- and other-race faces differently. *PLoS One, 6*(4), Article e18621. https://doi.org/10.1371/journal.pone.0018621

Wilson, M., & Daly, M. (1985). Competitiveness, risk taking, and violence: The young male syndrome. *Ethology and Sociobiology, 6*(1), 59–73. https://doi.org/10.1016/0162-3095(85)90041-X

Wind, A. E., Takken, T., Helders, P. J. M., & Engelbert, R. H. H. (2010). Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? *European Journal of Pediatrics, 169*(3), 281–287. https://doi.org/10.1007/s00431-009-1010-4

Windhager, S., Bookstein, F. L., Mueller, H., Zunner, E., Kirchengast, S., & Schaefer, K. (2018). Calibrating facial morphs for use as stimuli in biological studies of social perception. *Scientific Reports, 8*(1), 6698. https://doi.org/10.1038/s41598-018-24911-0

Zebrowitz, L. A. (2018). First impressions from faces. *Current Directions in Psychological Science, 26*(3), 237–242. https://doi.org/10.1177/0963721416683996

Zebrowitz, L. A., & Collins, M. A. (1997). Accurate social perception at zero acquaintance: The affordances of a Gibsonian approach. *Personality and Social Psychology Review, 1*, 204–223. https://doi.org/10.1207/s15327957pspr0103_2

Zebrowitz, L. A., & Montepare, J. M. (2008). Social psychological face perception: Why appearance matters. *Social and Personality Psychology Compass, 2*(3), 1497–1517. https://doi.org/10.1111/j.1751-9004.2008.00109.x